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Europe Report

SCIENCE AND TECHNOLOGY

POLAND: SCIENCE AND TECHNOLOGY ACHIEVEMENTS

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ACADEMY OF SCIENCES SUMMARIZES ACHIEVEMENTS

Developments in Physics

Warsaw NAUKA POLSKA in Polish No 4, Jul-Aug 85 pp 17-33

[Article by Jerzy Kolodziejczak, corresponding member of the PAN [Polish Academy of Sciences]: "Status and Development Directions of Physics in Poland" (Footnote) (Text of a paper by the PAN Committee on Physics, presented by the Committee Chairman Corresponding Member of the PAN Jerzy Kolodziejczak at the Plenary Session of Department III of the PAN held on 16 Sep 1984 in Warsaw)]

[Text] I. Introduction

The present paper was prepared on the basis of a detailed analysis of the situation in discrete branches of physics, performed by specialized sections of the PAN's Committee on Physics. This analysis, covering the period since the Second Congress of Polish Science, was performed by:

-- Section on Condensed Phase Physics.

-- Section on Nuclear Physics.

-- Section on Molecular Physics.

-- Section on Optics and Spectroscopy.

-- Team for Publishing Houses.

The scope of this paper permits only an overall review of the extremely extensive and detailed studies carried out by the above sections. Separately from these actual studies, an extensive paper on the status and development directions of physics in Poland was presented during the 24th Congress of Polish Physicists in Torun in 1979. It also has been published in toto in NAUKA POLSKA, No 11, 1979. That paper treated comprehensively the development of physics in Poland over a lengthy period of time commencing as far back as the end of World War II. Its part pertaining to recent years remains largely topical even now. In addition, an extensive paper by Prof Z. Wilhelmi, "Status and Development Prospects of Nuclear Physics," has been published in NAUKA POLSKA, No 1-2, 1983. In view of the above, it appears justified to present at

present only a summary treatment of the problems of the development of physics in Poland, and only for the recent period at that, on largely focusing attention on future prospects.

As ensues from the analysis of the current state of physics in the world and its development trends, the resolutions of the Second Congress of Polish Science concerning the development directions of physics in Poland have proved to be in most cases justified. These resolutions, which took into consideration the strong scientific schools already existing in Poland, apply to all the major branches of physics such as:

1) Experimental and theoretical physics of the atomic nucleus and elementary particles;

2) Atomic and molecular physics as well as quantum optics;

3) Solid-state physics with special consideration of semiconductors, dielectrics, magnetic materials, and superconductors;

4) Physics of extremal states of matter;

5) Observational and theoretical research into astronomy and the related branches of physics.

The resolutions of the Second Congress of Polish Science allowed for the fact that physics is, by nature of things, a most fundamental natural science, whose object of inquiry is problems relating to the most fundamental laws governing the world of inanimate matter. The discoveries of physics regarding such elementary concepts as time, space, energy, matter, symmetry, etc., not only exert tremendous influence on the broadening of knowledge about our surroundings but also are decisive to the rise of new directions in philosophy and the development of the scientific world outlook, and thereby, speaking most broadly, they are a crucial culture-promoting factor. But while perceiving this role of physics, the last congress of Polish science, did not overlook its equally important role represented by its generation of scientific foundations for world technology progress. This role of physics, relating to the practical application of its discoveries, causes this science to be included among the principal factors decisive to the development of mankind's scientific and technical civilization.

Precisely these two faces of physics constituted at the Second Congress the point of departure when determining the directions of physics research in Poland. In these directions allowance was made for theoretical research of the most fundamental significance to the cognition and understanding of the material world, such as space-time structure, the theory of gravity, the elementary structure of matter, unification of known physical effects, evolution of the universe as a whole, etc. In addition, allowance was made in research topics for those fields of physics which provide knowledge that is directly linked to the development of technology as such and technological progresss in other scientific disciplines. In view of precisely this broad scope of influence of physics and its effect on the development of such sciences as astronomy, biology, chemistry, medicine, various engineering

sciences, etc., physics can be regarded as one of the most interdisciplinary domains of science.

II. Assessment of the Implementation of Resolutions of the Second Congress of Polish Science With Respect to Discrete Fields of Physics

1. High-Energy and Elementary Particle Physics as Well as Nuclear Low-Energy Physics

The research into the field of broadly conceived nuclear physics comprised topics relating to high-energy and elementary particle physics as well as to low-energy nuclear physics, i.e., the atomic nucleus.

In high-energy and elementary particle physics there occurred in the world after 1974 a vigorous development of completely new directions of research, such as research into quarks, gluons and weak-interaction bosons. Polish physicists participated very intensively in this new research, although it was not included in the directions recommended earlier by the Second Congress of Polish Science. In particular, worldwide and domestic research into new kinds of fundamental particles has grown in recent years, This research points to the advent of a portentous synthesis of various types of natural interactions. We are thus witnessing a period of great changes in the development of physics. The nature of experimental research as well is changing, and it requires to an even greater degree the utilization of the giant experimental facilities operated by international research centers such as the European Center for Nuclear Research (CERN) in Geneva. In addition, at the interface between the physics of elementary particles and nuclear physics there has recently arisen a new domain of physics -- relativistic nuclear physics, the physics of high-energy ion interactions, which is practiced in Poland chiefly owing to the international cooperation of scientists concentrated round the United Institute of Nuclear Research in Dubna.

High-energy physics is currently recognized internationally as a Polish specialty. Among the socialist countries, Poland ranks next to the USSR in that domain of physics. Polish high-energy physics has attained its present position owing to the rise of two strong scientific schools, in Krakow and Warsaw. The formation of these schools and the high opinion enjoyed by the works of Polish physicists made possible their access to giant accelerators in international and foreign research centers. Participation with international partners in research programs is possible owing to the construction in this country of part of the apparatus needed to record the course of the phenomena investigated. The research conducted has produced many fundamental results of both applied and basic significance. For example, the discovery of hypernuclear matter in Poland has led to the rise of a new domain of nuclear physics to which thousands of studies have been devoted, with the related findings being included in textbooks of modern physics. High-energy physics is a domain of science that is of a basic rather than applied nature. In view of, however, the high technology and sophisticated equipment it employs, it is becoming a source of technical progress. Unfortunately, in recent years proper conditions for the development of this important direction of Polish physics have not been assured. This domain of science, which everywhere in the world requires intensive international cooperation, and international

competition as well, can develop properly in Poland only on condition that the indispensable facilities and computational means be provided in this country.

Pursuant to the recommendations of the Second Congress of Polish Science, it was determined that physics of the atomic nucleus has been included among the priority directions of physics research. This direction of research has been funded under "Key" Program 0.43 and under Interministerial Program MR 1.5.

The resolutions of the Second Congress postulated equipping research centers with up-to-date apparatus and facilities. In this connection, the construction of two accelerator facilities was undertaken: a double heavy-ion cyclotron (AJC 144) in Krakow and a heavy-ion cyclotron (C-200) in Warsaw. The economic crisis caused the suspension of both projects. In Krakow, tests with the internal beam are envisaged for not sooner than next year, while the construction of the cyclotron in Warsaw still encounters difficulties owing to the absence of a final decision on this matter by the authorities.

Despite these difficulties, Polish nuclear physics has implemented by dint of utmost effort and commitment a majority of its planned research projects. This was possible owing to the advance training of large numbers of competent science personnel as well as to broad international cooperation. Emphasis should be placed on the importance of Polish participation in the work of the UINR in Dubna to the development of nuclear physics in Poland.

Theoretical and experimental work was carried out on:

1) collective states of atomic nuclei, also at high rotations and high excitation energies;

2) emission of particles from highly excited states and nuclear fission;

3) complete and partial nuclear fusion and quasimolecular systems;

4) deeply inelastic reactions, break-up and transfer;

5) nuclei distant from the stability path and superheavy nuclei;

6) giant resonances.

This research represents a major contribution of Polish physicists to world science during that time. Much of this research has become a permanent part of textbooks and monographs in the field.

In addition, it should be emphasized that both the physics of elementary particles and nuclear physics have often provided spinoff in the form of highly advanced technologies for other fields of science and industry, as may be exemplified by the electronic technology of the CAMAC system, which has become an export item. In the laboratories of physics of the atomic nucleus were generated such domains of engineering physics new to Poland as: reactor physics, hot-plasma physics, accelerator physics, and nuclear geophysics. In this country, too, various nuclear techniques -- the neutron, activation,

Mossbauer, and nuclear resonance techniques -- developed and are being widely applied in various sciences and in technology.

2. Molecular Physics

In addition to nuclear physics, semiconductor physics and the physics of magnetic materials, molecular physics has been a rapidly developing field in this country, thus fulfilling the resolutions of the Second Congress of Polish Science. In many specialized domains Polish molecular physics has attained or maintained the highest world level. This includes: exact computation of molecular potentials, theory of nonlinear effects, one-dimensional systems, network dynamics, molecular mechanisms of phase transitions, photophysics, and others. Not all of these domains were named in the directions of physics development outlined by the Second Congress, and initiating research into them was dictated by the rapid development or intensification of new research directions in world science, such as molecular magnetism, dynamics of fluids and solutions, the development of the theory of nonradiative transfer, or the broad practical application of resonance and radiospectroscopy methods (e.g., in medicine).

The general purpose of molecular physics is to investigate elementary molecular and model systems and utilize the resulting findings to investigate the properties and effects of complex systems such as polymers, carbon compounds, protein structures, crystal structures, and ultimately perhaps even research into living tissue. By the same token, molecular physics often operates at the boundary lines of other scientific disciplines, such as chemistry, photochemistry, biophysics, biochemistry, molecular biology, and even medicine. This eminently interdisciplinary nature of molecular physics has grown markedly in the last decade, particularly at its interface with biophysics and biochemistry, and in practical applications in medicine (development of structural principles of the Polish tomograph).

Research into molecular physics in Poland has been conducted at 58 laboratories concentrated chiefly in seven research centers: Poznan, Wroclaw, Krakow, Warsaw, Torun, Gdansk and Lodz. The Poznan center handles radiospectroscopy and nonlinear optics; the Wroclaw center, spectroscopy and molecular crystals; the Warsaw center specializes in theory of molecular intreactions, molecular spectroscopy and photophysics; the Krakow center engages in radiospectroscopy and molecular crystals, employing optical spectroscopy and neutron scattering; the Torun center is traditionally linked to methods of optics and molecular systems; the Gdansk center develops molecular acoustics and molecular spectroscopy; and lastly the Lodz center does polymer research. Each of these centers is developing experimental techniques and methods of modern theory. Research into molecular physics is funded by the interministerial programs MR.1.9, M.R.1.5 and MR.1.4.

Although molecular physics is a relatively inexpensive field of research, since it does not demand gigantic facilities and the importance of its findings depends rather on the finesse of the concepts and techniques employed, its development in recent years has been clearly impeded by shortages of modern research equipment (in particular, rapid electronics) and the underdevelopment of methods of laser spectroscopy and cryogenics in this country.

The resolutions of the Second Congress of Polish Science also mentioned the development of cryogenic research, which should proceed on the basis of the helium in Odolanow. Hence, an IFM PAN laboratory has been organized at the Natural Gas Denitrogenating Plant in Odolanow with the object of developing low-temperature equipment and utilizing it in Polish science. The scope of the related research has so far been modest, because that laboratory is only commencing its activities.

3. Solid-State Physics

The special significance of solid-state physics consists in its tremendous influence on the development of modern technologies. In this field the boundary line between basic and applied research is blurred. Along with nuclear physics, solid-state physics has hugely influenced the development of the scientific and technical civilization and the industrial world in the second half of the 20th century. This is related in particular to the still continuing revolution in the field of modern electronics, whose scientific foundations were created owing to epochmaking discoveries in the field of semiconductor physics, magnetic materials and dielectrics. The revolution in electronics has led to the rise of totally new fields of science and technology that are exerting a fundamental influence on the development of the modern world. Suffice it to mention here as examples information science, modern telecommunications based on the use of satellite technology, the achievements in the automation and remote control of production processes, the development of space research, etc.

This importance of solid-state physics was perceived by the Second Congress of Polish Science, which formulated the development directions of this field of physics in Poland. At present, from the vantage point of time, it can be stated that the research tasks outlined by the Congress were in principle consonant with the world trends. The principal directions of solid-state physics developed in Poland have included: the physics of semiconductors, magnetic materials and dielectrics relating to structural research; crystal-growth and surface physics; and the physics of interphase boundaries. In the field of semiconductor research the following subjects received principal attention:

-- Structural research, with special consideration of the real structure of crystals and the analysis of the generation of defects. This kind of research is of fundamental importance to improving crystallization processes and the methods of quality control required to develop the technologies of the materials used in electronics.

-- Research into free-electron dynamics in semiconductors, with special consideration of band structure and scattering processes. Aside from the fundamental cognitive significance of this subject, attention should also be drawn here to its practical importance due to the fact that electron "mobility" is the determining factor in many practical applications of semiconductors.

-- Research into the role of the electrons relating to lattice impurities and defects. This direction of reseearch is closely linked to the optical properties of semiconductors. Of special practical importance in so-called optoelectronics are the luminescent propertiers of semiconductors as determined by electron processes of radiative and nonradiative recombination.

-- Development of semiconductor materials with new properties. In this field has occurred a Polish-initiated intensive development of the technology of the so-called semimagnetic semiconductors combining in themselves the features of semiconducting and magnetic materials.

In the above research varied experimental techniques have been employed, with special consideration of electrical x-ray and electronmicroscopic methods, many spectroscopic techniques comprising a broad band of the spectrum, and microwave techniques. The research has been conducted under various conditions allowing for high pressures, low temperatures and strong electrical and magnetic fields.

Semiconductor research has been carried out chiefly at the Warsaw center, which is the main center for basic and applied research in this field. Owing to the system for coordination of research, research teams at other centers, e.g., those in Wroclaw, Katowice, Krakow, Lublin, and Torun, have been enlisted in this research.

In the field of the physics of magnetic materials research has been focused on exploring the electron structure of the following two major groups of materials:

-- monocrystalline d- and f-electron materials, chiefly intermetallic actinide and lanthanide compounds as well as oxides;

-- materials with disturbed crystalline and magnetic ordering, including amorphous materials and spinels.

Of basic cognitive and practical importance has been the research into magnetization processes in the abovementioned groups of materials, in connection with investigation of changes in domain structure under the influence of the magnetic field and temperature.

Many new technologies for producing magnetic materials have been worked out and new research methods developed, such as tunneling-electron spectroscopy or an original -- on the world scale -- method for observing domain structures based on the cryocondensation of oxygen particles. Of the numerous important findings made during the period under consideration, the following deserve special emphasis:

-- discovery of giant anisotropy and magnetostriction in lanthanide compounds;

-- identification of the mechanisms determining the magnetoelastic properties of amorphous alloys;

-- discovery of the coexistence of magnetism and superconductivity in Y_4Co_3.

Research into the physics of magnetic materials has been carried out at many laboratories in Poland. It has been raised to a particularly high level at research centers in Warsaw, Wroclaw, Krakow, Poznan, and Katowice.

During the period in question considerable advances in research into ferroelectrics have also been made in Poland. The results obtained in this respect have, in addition to their great importance to science (such as research into so-called incommensurate phases or the discoveries of new ferroelectrics), also found practical application. The leading role in the field of the physics of ferroelectrics belongs to the Wroclaw and Poznan centers.

Since the Second Congress of Polish Science structural research that represents a bridge linking various directions of solid-state physics has been successfully conducted in Poland. Research into the real structure of crystals and its effect on the physical properties of materials has become a Polish specialty. Emphasis in this field is deserved by the development of many new research techniques, especially x-ray, electronmicroscopic, neutron, resonance, ultrasonic, and implantation techniques. Studies of solid-state microstructure and microdynamics have also been conducted by means of methods of nuclear physics. Methods of Mossbauer spectroscopy, disturbed correlations, angular decomposition of radiation, and positon annihilation have been employed. This research has been particularly developed at the Warsaw, Krakow, Wroclaw and Lublin centers.

The development of solid-state physics in Poland has been markedly influenced by research into extremal states, particularly at low temperatures and under high pressures. Interesting results have been obtained as regards the physical properties of new superconductors with A-15 structure and Chevrel phases. New techniques and equipment required for high-pressure research have been developed.

Research into both crystal and magnetic phase transitions has become an important direction of solid-state physics.

Summing up, it can be stated that the resolutions of the Second Congress of Polish Science concerning solid-state physics have been nearly completely implemented.

The directions of research corresponded to the actual world trends. However, its scope could have been broader had not it been for the drastic restrictions imposed in the mid-1970's on foreign-exchange subsidies for the acquisition of unique equipment and scientific books and periodicals. The maintenance of the world level in certain fields became possible owing to broadly expanded international cooperation providing our physicists with access to the world's best-equipped laboratories. Even so, however, underinvestment has adversely affected to a large extent many important research directions. The underdevelopment of metal physics still persists. Similarly, such an important field as the physics of surfaces and interphase boundaries has not been adequately developed. The consequences of the drastic underdevelopment of crystal-growth physics, which requires modern and costly research equipment and technologies, have been particularly adverse to the linkage of solid-state physics to the needs of the Polish electronics industry

4. Optics and Spectroscopy

As regards optics and spectroscopy, the Second Congress of Polish Science postulated the development of this field in three major directions:

-- Atomic spectroscopy;

-- Molecular spectroscopy;

-- Nonlinear and quantum optics along with holography.

Considering the present status of optics and spectroscopy in Poland, marked progress in all the above research direction can be observed. Our physicists working in this field of knowledge have consolidated their already solid position in world physics. The resolutions of the Second Congress of Polish Science were not fulfilled in physics chiefly as regards providing laboratories with research facilities. The most important facilities that the physicists had not received are: an ion accelerator for research by the target beam method, tunable high-class dye lasers, many spectrometers -- principally Fourier spectrometers -- and multichannel optical analyzers. There was also a shortage of much other laser, optoelectronic, etc., apparatus, including small computers provided with interfaces for on-line operation. These shortages considerably impeded research. Even so, despite the unfavorable funding conditions, certain scientific discoveries and accomplishments of Polish physicists have been of high rank. These achievements were made by dint of considerable effort, both in this country and through cooperation with foreign research centers, which helped maintain the worldwide high level and prestige of Polish science in optics and spectroscopy. For the Poznan center these accomplishments include: theory of compressed states self-induced by a phase transition in the laser beam (self-squeezing) propagated in a nonlinear center; work on the theory of the multiphoton laser; research into the dynamics of chemical and isomeric reactions in biological systems; accomplishments in the development of and research into stoichiometric laser materials; synthesis and growth of stoichiometric crystals; production of laser action in the visible band on color centers; the discovery of a laster tunable to emerald crystals at vibrational transitions (patent [obtained]); research into the phase-coupling effect in molecular systems,serving to

isolate the correlation function of single molecules and intermolecular effects; and the development of a single laser pulse autocorrelator for measurement of ultrashort pulses, based on the phase-coupling effect. As for the other research centers, the development of an interferometric method for active phase modulation of dye lasers at the Warsaw center deserves mention, as does the activation of a technological production line for fiber optics for telecommunication needs at the Lublin center. The accomplishments in quantum optics (Warsaw) and atomic optics (Torun, Krakow), as well as in stochastic methods, the wavefront reversal effect, light statistics, etc., and also as regards dye lasers (Torun, Krakow, Warsaw) have been considerable.

Currently many centers for research into optics and spectroscopy operate with laser equipment that has chiefly been constructed in this country, incorporating a small quantity of imported components. The supply of XLA 120 ion lasers built by Carl Zeiss Jena is also satisfactory. In general, however, the systems constructed with our own resources lag markedly behind the class of equipment produced abroad, chiefly owing to the shortage of such components as continuous-action flash and arc lamps, special diffraction gratings and many other optical components that are not being domestically produced. The equipment problem has been in the last few years greatly compounded by the nearly total lack of foreign exchange. A domestic optics industry has not developed as regards lasers and other measurement apparatus. The production of certain lasers initiated by the PZO [Polish Optical Plants] has been discontinued, and the efforts of the COBRABiD are, in view of the inadequate technical resources, incommensurate with the needs. Here it should be emphasized that certain projects, such as monochromators, illuminators, laser amplifiers, and radiation meters developed by the COBRABiD as well as the holographic sets developed by the PZO, have been quite successful. Unfortunately, their production has often been confined to the first series, without being continued in the subsequent years. Hence, research collectives have largely to rely on constructing their own equipment, but this kind of effort consumes a great deal of valuable time that should have been spent on basic research. Basically, no spectroscopic equipment is being produced in this country. Its principal suppliers are the GDR and the USSR. The possibilities for acquiring this equipment from other countries are nugatory. Thus, further development of experimental research largely hinges on the construction of our own equipment through small-series production. Here it should be emphasized that a large number of completed and relatively good domestic designs is in existence at present, but they are not being produced in large series.

III. Prospects for Further Development of Physics Research

The main directions of research in the physical sciences, as recommended by the Second Congress of Polish Sciences, should in principle remain topical in the subsequent years as well. In continuing the longrange research programs the criteria below, among others, should be followed:

1) Maintenance of existing scientific schools and assurance of a high world position in certain fields of physics achieved in previous years;
2) Adherence to the main thematic framework of the anticipated worldwide physics research;

3) Improved linkage of proposed research topics to the development needs of technology, industry and other scientific disciplines.

Taking these criteria into account, the following program assumptions may be formulated for discrete fields of physics:

High-Energy Physics of Elementary Particles and Nuclear Physics.

In the field of the physics of elementary particles, which is of basic cognitive importance to the natural sciences, previous research into elementary and nuclear interactions should be continued, on gradually devoting increasing attention and resources to major research programs associated with the great international research centers.

Experimental studies of elementary-particle interactions in the presence of high energies should be carried out, particularly those leading to the exploration of the quark-parton structure of hadrons, the properties of leptons and intermediate bosons, and the search for new elementary constituents of matter (e.g., quark-gluon plasma). In connection with this international effort and the concentration on research employing the currently built new-generation accelerators, it is particularly important to prepare and conduct experiments in the following domains:

-- studies of interactions of electrons with positons and protons;

-- studies of hadron-hadron interactions;

-- studies of interactions of hadrons and leptons with atomic nuclei.

In connection with the construction of new particle-acceleration centers abroad (UNK in the USSR and SSC in the United States), plans should be made for the participation of Polish teams in next-generation experiments. The present economic potential of this country does not warrant considering the construction of a high-energy particle accelerator in Poland, but a radical improvement in the supply of equipment and computational means, as well as in the flow of scientific information, is needed.

The research into the physics of cosmic radiation being conducted by the Lodz center fruitfully and at a high European level should continue to be fostered. This research combines problems of the physics of elementary particles and space physics -- two fields of physics whose cognitive importance at present is particularly great.

Nuclear physics is of great importance, both cognitively and in practice, particularly in this era of the development of nuclear power and applications of techniques of nuclear physics to other fields of physics, to natural sciences, to industry, medicine, agriculture, and problems of environmental protection. Nuclear physics should continue to be a research priority.
In accordance with the world trends of science, the following should be developed in Poland:

1) research into properties of nuclear matter and atomic nuclei with the aid of heavy-ion accelerators, both Polish (C-200 in Warsaw, AJC 144 in Krakow) and those accessible abroad;

2) research into the structure of atomic nuclei and the properties of superheavy nuclei;

3) experimental research into density decompositions of nuclear matter and shapes of nuclei in the presence of high spins, and into the dynamics of their changes;

4) research into polarization effects in nuclear reactions;

5) research into giant resonances;

6) exploration of the equation of state of nuclear matter in various excitation and density domains, with astrophysical implications;

7) research into reactions induced by fast nucleons;

8) cosmological studies and research into the evolution of galaxies and stars as based on linking nuclear physics to physics of elementary particles, theory of gravity and theory of relativity.

A prerequisite for achieving these goals is the completion of the construction and equipping of the cyclotrons in Warsaw and Krakow and the development of up-to-date computerized methods for the detection and identification of nuclear radiation. Only the availability of suitable facilities in this country can make it possible to train a new cadre of specialists, to conduct research work in this country and to continue foreign cooperation on partnership basis. At the same time, this will make possible full concentration on the research subjects and an economical utilization of the available resources.

It should be pointed out that international cooperation in nuclear physics will always be of basic importance in view of the access to large internationally utilized research installations which we lack in Poland. This is of special importance to high-energy research.

We should also join in the development of research into the effects of intermediate- and relativistic-energy heavy ions. This new domain of physics, which is vigorously developing in the world, can be very effectively developed in this country, while interdisciplinary research into the effects of low-, intermediate-, and high-energy heavy ions can produce considerable cognitive results (exotic nuclei, nuclear matter in extremal states, quark-gluon plasma). Once the Krakow and Warsaw centers are provided with heavy-ion accelerators, the related research could combine the physics of elementary particles with nuclear physics and will assist Polish nuclear physics to enter upon a new road of development that has been impeded in recent years owing to the lack of basic research equipment.

Molecular Physics.

Molecular physics is of great cognitive importance, augmented by the fact that its findings are applied to other fields and disciplines of science. It also is important to industrial practice and applications and in this respect, according to forecasts for the development of electronics and informatics over a prolonged span of time (around or after the year 2000), its qualitative share should markedly increase.

The accomplishments so far of Polish molecular physics and the current world trends in this field indicate that the directions of the related research in Poland have been properly selected. They should be continued and developed, on concomitantly focusing the domestic research potential on such fields as:

1) Radiospectroscopy;

2) Electronspectroscopy and spectroscopy of excited and transition states;

3) Molecular interactions conditioning the structure, dynamics, and specific properties of molecular systems and phases;

4) Polymer physics;

5) Ferroelectrics and other special dielectrics;

6) Molecular crystals, low-dimensional systems and fluid crystals;

7) Molecular magnetism.

All these fields and subjects should be purposely directed and centrally coordinated and determined within the framework of an integrated research program for the next 5-year period.

In the next few years it will be necessary to speed up measures to effectively utilize Polish helium in science and practice on the basis of the aforementioned IFM laboratory in Odolanow.

In addition, marked progress in, and the final initiation of, the production of Polish tomographs should be expected within the next few years.

A separate problem is thhe need for molecular physics to launch even now a headstart program in the field conventionally termed "molecular electronics." The development of electronics and allied branches, e.g., optoelectronics, displays a consistent trend toward miniaturization. This trend is leading to a situation in which individual multiatomic particles will play the role of electronic elements, switches. This trend is even now regarded seriously by scientists and electronics industry in the highly developed countries of the West. It is a crucial issue for Polish molecular physics, too, even now to engage in this direction of basic and materials research, so that the next coming technological leap in 15 or 20 years would be no surprise to Polish science and technology.

Solid-State Physics.

The main research directions in solid-state physics recommended by the Second Congress of Polish Science should in principle remain topical in the coming years. In view of the cognitive significance and possible applications of this physics in electronics, cryogenics, computer engineering, and automation, as well as in the solution of problems of energy conversion and the synthesis of new materials, it is to be expected that solid-state physics will continue to be a major direction of physics research. In particular, research into semiconductors, magnetic materials, metals, superconductors, and dielectrics will be developed. In all these groups of materials the following principal research subjects are emerging:

1) phase transitions;

2) crystal structure;

3) real structure and diagnostics of crystalline materials;

4) electron structure and magnetic structure;

5) superstructure, i.e., so-called superlattice;

6) materials technology and crystal growth physics;

7) surfaces, thin layers, and interfaces;

8) elementary excitations;

9) quasiunidimensional materials;

10) spectroscopy in all regions of the spectrum;

11) composite materials;

12) implantation;

13) low-temperature physics;

14) high-pressure physics;

15) strong electrical and magnetic fields.

In all these domains of research stress should be placed on a well-coordinated linkage of cognitive aspects to applications. In structural research, e.g., this is related to the need to develop new techniques for the diagnostics of materials, particularly the materials indispensable to the development of the electronics industry. Technologies serving to identify and investigate crystal impurities and defects should be further developed. Similarly, research into effects ensuing from the specific dynamics of electrons in crystals, including band structure and scattering processes, should be continued. In view of the expected growth of optoelectronics and integrated optics, research into

specific properties of optical solids should be continued, with special consideration of radiative and nonradiative recombination processes in semiconductors. Intensive exploration of semiconductor, magnetic and dielectric materials with new properties of interest to applied research is still indispensable. In this context, research into semimagnetic semiconductors has to be continued. In view of the cognitive importance of crystal growth physics and its particularly close ties to the needs of electronics industry, it is essential to overcome the lag in this domain of physics. Elevating the level of this domain to the proper extent is a prerequisite for the industrial application of the domestic scientific accomplishments in the physics of semiconductors and magnetic materials. It appears that an effective solution would be the formation, jointly with industry, of a research laboratory focusing on materials of special importance to the development of electronics, such as semi-insulating gallium arsenide. Such a laboratory should undertake research into the synthesis of special structures and superlattices conditioning the development of rapid electronics. Among the neglected fields, research into the physics of surfaces and the physics of the electron states present at interphase boundaries needs to be intensified.

In research into magnetic materials, special emphasis should be placed on exploration of new materials, particularly those in the group of lanthanide and actinide compounds characterized by a high magnetocrystalline anisotropy and a strong spin-lattice coupling. In addition, rising importance is being attached to research leading to a complete understanding of the effect of inhomogeneities on the magnetic properties of crystals, and to mastering techniques of inhomogeneity control with the object of synthesizing materials with qualitatively new properties.

In addition to the above subjects, which belong within the scope of classical solid-state physics and technology, attention should be paid to interdisciplinary problems linked to the development of such fields as low-temperature physics and technology, high-pressure physics, and the physics of strong magnetic fields. These fields of physics comprise, on the one hand, an extensive domain of intrinsic problems of physics of a cognitive nature, while on the other they provide the basis for the development of new research methods and techniques in solid-state physics.

Optics and Spectroscopy.

Research into optics and spectroscopy is not integrally contained in any centrally coordinated plan. During the years 1970-1975 quantum electronics research was integrated in a targeted "key" program and the fulfillment of the related plans provided the foundations for its development, but unfortunately that program was prematurely terminated. During the years 1975-1980 work on that program was restricted to building specific laser equipment. Entrusting the coordination of that program to the quondam OMEL Association culminated in a complete fiasco. At present, the related research is dispersed among a large number of centrally coordinated and local research plans. Hence there exists an important need for integrating problems of optics and spectroscopy within a single centrally coordinated research plan in which adequate provision would be made for basic research, side by side with problems of the construction of

equipment and applications. The Section on Optics and Spectroscopy under the PAN's Committee on Physics could exercise patronage over this matter.
Emphasis should also be placed on the need for a broad development of new research technologies utilizing optical phenomena in chemical, biological, and even medical research. By participating in such interdisciplinary research the community of opticists is fully prepared to make a contribution to, among other things, the food program and the public health program.Below are the principal scientific problems that should be worked on in optics and spectroscopy:

-- Theoretical research into the generation and propagation of light pulses in atomic resonance centers; reserch into phenomena of light-wavefront reversal.

-- Research into multiphoton processes and parametric effects of various types, including processes resulting in polarized beams of electrons or atoms.

-- Research into the movement and radiation of electorn beams in electromagnetic structures, from the standpoint of applications in free-electron lasers.

-- Research into classical- and laser-light statistics; effects of the bunching and dispersal of photons; research into squeezed states; development of stochastic methods in quantum optics.

-- Theoretical analysis and experimental studies of nonlinear optic phenomena.

-- Basic research into quantum electronics; exploration of new laserizing materials (e.g., stoichiometric crystals, crystals with color centers; new laser dyes; anisotropic materials with a high active ion concentration, semiconductors.

-- Construction of various types of laser equipment (high- and low-power systems, including tunable dye lasers, nitrogen lasers, etc.).

-- Research into atomic and molecular systems by means of techniques of high-resolution spectroscopy (saturation spectroscopy, polarization spectroscopy, spectroscopy free of the Doppler effect, quantum beat method, CARS method, Fourier spectroscopy).

-- Theoretical and experimental research into the electron structure of solids, with special consideration of semiconductors.

-- Research into properties of atomic nuclei with the aid of techniques of interference spectroscopy.

-- Research into inter- and intramolecular interactions in luminizing systems in excited states in nonpolar and polar solvents.

-- Research into the effect of laser radiation on macromolecular systems (ribonucleic acids, tRNA, hemoglobin, etc.) -- also from the standpoint of applications in detection and treatment; research into the conformation and dynamics of tRNA acids.

-- Research into processes of photosynthesis on, among other things, a picosecond scale of time.

-- Research into holography and optical data conversion.

Work on these subjects will be possible on condition that the laboratories be provided with the needed equipment and assured sufficient funds. Given the current price level, a level of about 2-3 million zloty annually per researcher would be satisfactory, with part of that amount to be in the form of foreign exchange. Much attention should be devoted to international contacts, which are indispensable to maintaining a high level of science personnel. A crucial matter is the assurance of broad access to books and periodicals. Considerable advantages are produced by the organization of conferences of an international scope (consider the good tradition of the Quantum Optics Schools and the EKON Conference) as well as participation in foreign conferences. The greatest emphasis, however, should be placed on cooperation and staffing at centers of established high scientific importance. Lastly, modern optics cannot develop without a concomitant development of classical optics, that is, without the manufacture of basic optical components.

IV. Conditions for the Development of Physics in Poland

The fields of physics considered above comprise the subjects of research conducted more broadly at many research centers in this country. Many large institutes and scientific laboratories associated with the higher educational institutions and the Polish Academy of Sciences engage in the related research. But a balanced develoment of physics in Poland requires the continuation and development of physics research also in the fields to which less attention is paid in this country and in which smaller research teams, or even individual scientists, are working. This quantitative smallness does not signify a low level. Most often, it ensues from the nature of the research conducted. There does not exist, e.g., any natural need for establishing large research centers in certain fields of theoretical physics. The teams existing so far should be provided with the indispensable conditions for continuing their research at the highest world level in such fields as the general theory of relativity with special considerations of gravity problems, quantum chromodynamics and problems of so-called "grand unification," quantum electrodynamics, statistical physics, etc. The markedly dispersed Polish research into plasma physics should be substantively concentrated in one place. Work on physics subjects linked to space research also has to be continued. In addition, the high position of our astronomy and astrophysics should be maintained regardless of cost.

The further development of the physical sciences in Poland, as linked to the initiation of highly ambitious thematic research, requires meeting many elementary conditions such as, primarily:
1) Provision of laboratories with indispensable modern research facilities and the maintenance of existing facilities ([by providing] spare parts]).

2) Completion of the construction of the C-200 accelerator in Warsaw and the AJC-144 accelerator in Krakow.

3) Modernization and expansion of computational facilities and the establishment of computerized linkage with major international physics centers.

4) Improvements in the flow of scientific information by assuring an ongoing supply of books and periodicals for science libraries and developing the general printing industry facilities. In addition, development of in-house -- much less expensive and cheaper than traditional -- printing and xerographic facilities.

5) Development of intensive international cooperation, which is lever of progress in modern physics. In particular, development of effective means of co-operation with major foreign centers operating research facilities not available in this country (ion accelerators, synchrotron radiation sources, ultravacuum spectrometers, etc.) and employing high technology that is not yet available in this country.

6) Provision of conditions for training science personnel at the highest possible level, particularly by developing modernly equipped specialized and local laboratories and assuring access to them for undergraduate and doctoral students as well as for regular science personnel.

7) Provision of conditions for an improved application of scientific research in engineering and other branches of physics (training of specialists and managers as well as greater popularization of the achievements of physics).

8) Establishment of a cryogenics facility that would, in particular, assure mastering the production and distribution of liquid helium on a nationwide scale.

A major problem in the application of the results of scientific research to the national economy is the development of new organizational forms for streamlining that application. In view of the great complexity of innovation problems, considerable flexibility and diversity of solutions is needed. There is a need for both refining the already existing solutions and devising new ones.

New organizational forms should make possible to rise of a small-scale industry active at the boundary line between science laboratories and big-industry enterprises. Small enterprises can effectively utilize minor inventions which, owing to their nature, lie outside the scope of interests of big industry (the polls conducted indicate that there exist many such inventions ready for practical application). In addition, such enterprises

will play a major role in expediting the application of new technologies in big industry. A direction whose development seems highly promising is the formation of small specialized production-application teams, chiefly in the form of joint partnerships of authors of inventions, their parent agencies and interested enterprises. To facilitate the development of such organizations, the question of the legal entity of science laboratories has to be settled. The issue of the practical application of scientific accomplishments should also be more properly appreciated and understood within the community of the physicists themselves.

On analyzing the worldwide development of physics, a certain definite pattern is established. The role of physics is particularly appreciated in the countries whose economies are most strongly developed, and whose industry operates at a high level such that its further development is possible only on the basis of direct reliance on science for inspiration. Weakness of physics in a country is always a sign of its industrial and technological weakness. This pattern implies the existence of a direct relationship between physics, industry, and technology. Such a fact should not be ignored if the development of this country is to be regarded seriously. It would be worthwhile for both the so-called decisionmakers and the community of physicists themselves to draw the proper conclusions from this.

Chemical Sciences

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[Article by Jerzy Haber, active member of the Polish Academy of Sciences: "Current Problems of Chemical Sciences in Poland and Their Development Prospects" (Footnote) (The preparation of this paper was possible owing to the fact that our colleagues A. Bielanski, A. Bylicki, K. Cempiel, Z. Galus, A. Golebiewski, E. Goerlich, Z. Jedlinski, J. Kopytowski, J. Kroh, Michalski, M. Mikolajczyk, W. Moszczynski, S. Mrowec, J. Obloj, W. Ostrowski, R. Pampuch, S. Pasynkiewicz, A. Pomianowski, L. Sobczyk, W. Szelejewski, M. Wiewiorowski, A. Zamojski, and J. Ziolkowski, as well as the Committee for Analytic Chemistry, sent in detailed reports on the status and development prospects of discrete fields of chemistry, for which in this place I wish to express my thanks to them.)]

[Text] Chemistry, being a science of the structure of and changes in the molecules of which inanimate and animate matter is built, is a discipline of the natural sciences. Since the exploration of the laws governing changes in molecules, as well as of the relationship existing beteen their structure and the properties of the materials and synthetics built from them, makes it possible to master the methods for producing them, chemistry is at the same time a foundation for man's extensive and important technological activities. For chemical industry affects the development of the entire economy by providing raw materials and synthetics for practically all the other industries. The production of synthetic rubber, the cracking of crude petroleum into gasolines, the fabrication of lubricants, etc., precondition the development of the automotive industry; the production of synthetic fibers and dyestuffs is the basis for the textile industry; the development of agriculture hinges on the production of artificial fertilizers and crop

protectants; the production of plastics, adhesives and insulating and other materials is decisive to the construction industry; the synthesis of ferrites and perovskites and the synthesis of doped semiconductor crystals, for example, are the basis for the electronics industry, and so on. Hence also, in every industrialized country the developmental pace of chemical industry spearheads the growth rate of all the other branches of economy. It is estimated that this "spearheading factor" should be 1.2-1.5. It should be stressed at the same time that this concerns not so much quantitative as, above all, qualitative development, because chemical industry belongs among those industries which are characterized by a high rate of technological progress and a rapid growth in the number of new products. Hence also the development of scientific research is of particularly great importance to chemical industry, meaning both cognitive research serving to discover new substances with properties that are useful to various branches of industry and consumption and new chemical reactions assuring a more efficient production of already known substances, and technological research serving to apply the obtained findings on an industrial scale. In view of the rapid depletion of fossil energy sources and the growing danger of environmental pollution, priority should be given to activities serving to supplant energy-consuming chemical technologies as well as technologies involving a great deal of environmentally polluting wastes with energy-conserving and waste-free technologies. In addition, new chemical processes based to a maximally possible degree on domestic raw materials such as coal, sulfur, rock salt, and rare metals, should be developed.

Current Problems of Chemical Sciences

The most characteristic feature of the development of chemical sciences in the last 10 years has been the tremendous progress in understanding the nature and structure of chemical bonds. This progress became possible owing to, on the one hand, the rapid development of new research techniques, which in its turn was conditioned by the development of modern technologies. The employment of such techniques as photoelectronspectroscopy, Auger spectroscopy, microwave spectroscopy, electron energy loss spectroscopy, slow- and fast-electron diffraction, high-resolution electronmicroscopy, various kinds of absorption and emission x-ray spectroscopy, nuclear and electron magnetic resonance, infrared Fourier spectroscopy, and many others, has made it possible to obtain detailed information on atomic alignment, spatial distribution of atoms, near- and far-range ordering, electron density distribution, and interaction forces beteeen atoms and their energy levels. Moreover, the growth of computer engineering has made possible increasingly complex calculations by methods of quantum chemistry with the object of describing and elucidating the properties of complex molecular systems, investigating particles with distinct chemical, physical, and biological properties, and investigating the mechanisms of chemical reactions.

The increasingly greater understanding of the structure of chemical bonds and of the relationship between that structure and various properties of chemical molecules has created the foundation for, on the one hand, a purposively guided synthesis of products with specified properties, which made possible a particularly vigorous growth of such fields of chemistry as organic synthesis with special consideration of biomolecules, polymer chemistry, and materials

engineering. What is more, this has become the motive power for radical advances in the science of the mechanism of chemical changes and, through the mediation of new catalytic processes, it has made possible the mass production of many important substances with completely new practical applications. This has also made possible the elucidation of many phenomena occurring at interphase boundaries and in highly dispersed systems, thus assuring their practical utilization.

As regards organic synthesis, two basic directions of research may at present be distinguished. On the one hand, organic synthesis is purported to develop new synthesizing unit operations and new methodological concepts, while on the other it serves to develop syntheses of desired natural products that often have an extremely complex molecular structure and a high molecular weight. An unusually important role in the development of organic synthesis is played by the chemistry of organometallic and organometalloid compounds. Its dynamic growth has already resulted in the integration of those domains of science which formerly had been regarded as inorganic chemistry, organic chemistry, or biochemistry. The last decade has been a period of an unusually rapid development of the chemistry of organophosphorus, organosilicon and organosulfur compounds endowed with specific chemical properties, and by their introduction as new reagents for chemical synthesis. Organic compounds containing two or more metalloids in various structural combinations, such as compounds of phosphorus and sulfur and silicon, and others, have become important and even especially interesting. New compounds of tremendous practical importance have been synthesized, such as refining materials and biologically active compounds such as protectants and drugs or even new polymer syntheses.

As regards organometallic compounds, special attention is attracted by metal complexes with unusual degrees of oxidation and complexes with unusual ligands, e.g., polycentric or macrocyclic ligands. New vistas have been unlocked by the synthesis of carbene and carbine complexes as well as o-carbyl complexes. In all this research a major role is played by stereochemical problems, with interest being focused on asymmetrical syntheses resulting in products with the desired configuration and a high optical purity. Reactions of this type may be exemplified by the asymmetrical epoxidation of allyl alcohols, asymmetrical catalytic hydrogenation, or stereoselective synthesis based on chiral substrates.

In recent years purposive syntheses of natural products have been surfacing as a major research problem. This is linked to the vigorous growth of the chemistry of natural products. The number of new biomolecules isolated from biological raw materials and the knowledge of their physicochemical and biological properties are growing at a fast pace. Research is being extended to biomolecules with increasingly complex molecular, macromolecular and supramolecular structures, as well as to their complicated natural complexes (ribosomes, nucleosomes, viruses, cell membranes, mitochondria, chloroplasts, etc.).

Currently the point of gravity in total syntheses of natural products is shifting from the synthesis of the basic skeleton of the molecule and the introduction of corresponding functional groups to the attainment of

appropriate configurations of chiral centers, chiefly by means of asymmetrical induction or by using chiral constituent molecules. Oriented synthesis also includes obtaining analogues of biologically active natural compounds with a structural or stereochemical modification that is specified in advance.

Spectacular achievements in recent years include, e.g., the chemical synthesis and expression of the structural genes of certain proteins and ribonucleic acid (somastostatin, insulin, interferon, ribonuclease); the creation of foundations for the synthesis of enzymatic and hormonal proteins with programmed properties; the separation and sequential ordering of all ribosomal protein components and ribonucleic acids; and complete reconstruction of active ribosomes, that is, elucidation of the molecular foundations of the translation process, and many other discoveries.

For many years the attention of researchers has been attracted to the hydrogen bond in view of the tremendous role played by this type of molecular interactions in nature. On the one hand, this bond is a factor stabilizing higher-order molecular structures and deciding the intricate architecture of living matter, while on the other -- owing to their particular dynamic properties, hydrogen bridge bonds often are the sites of initiation of complex chemical changes.

The synthesis of compounds with curative properties continues to be broadly represented, with the current trend being toward stereoselective syntheses of optically active compounds with elimination of the separation of enantiomers by classical methods.

In addition to the synthesis of drugs, the synthesis of new pesticides accounting for the successes of modern agriculture is of great practical importance. In recent years preparations with an exceptional biological activity, characterized by high selectivity and low toxicity and reducing environmental pollution to a minimum, have been developed.

Let us now consider another priority field -- polymer chemistry. Dynamic growth of this discipline occurred in the 1960's owing to the demand of modern technology, and particularly of electronics, computer systems and space technology, for new polymers with special properties. Since the 1970's there has also occurred a growth of interest in research into natural polymers and their synthetic analogues performing biological functions. The importance of polymers as structural plastics successfully supplanting such classical materials as metal alloys, glass, ceramics, and wood, is steadily rising. This is related to the unique properties of polymers, namely, their resistance to atmospheric and chemical corrosion, their heat-insulating and nonmagnetic properties, and their low intrinsic weight combined with a relatively high mechanical strength. The use of polymers as semipenetrable membranes -- which in many processes for separating mixtures of chemical compounds is often the sole technically feasible solution -- is steadily growing. Such methods as dialysis, electrodialysis, micro-, ultra- and hyperfiltration, and also thermodialysis, make possible the separation of gaseous and liquid mixtures, the separation of suspensions and colloidal solutions, highly effective electrolysis, and the purification of industrial liquid wastes.

Last, emphasis should be placed on the steady advances in the production technology of synthetic fibers which, owing to the modification of the original monomers, appropriate control of the polymerization process, thread molding, and the use of various means of finishing, acquire increasingly better and, in many instances, new useful properties. The vigorous growth of the petrochemical industry, which provides substitutes for wool, cotton, silk, lumber, and even metals, has become a major factor in the improvement in living standards of the world's industrialized countries.

The growth of modern technology became possible largely owing to advances in the planned synthesis of materials with desired mechanical, thermal, electrical, magnetic, chemical, and other properties. In every field of modern industry a crucial role is played by new materials, and particularly by such inorganic-nonmetallic materials as the laminated, fibrous and semicrystalline forms of carbon, the nitrides and carbides of silicon, the oxides of zirconium and aluminum, and also mono- and multicomponent silica glasses. These systems are of fundamental importance to the production of composites as structural materials for high-temperature applications (conventional and nuclear power generation, Diesel engines, gas turbines, etc.). In addition, research into techniques of micropowder synthesis is being intensively developed. The interdisciplinary fields are represented by research into ceramics designed for microwave acoustics; integrated microwave systems; materials for optoelectronic systems; superconducting materials, semiconducting materials, and other special materials for electronics. Underlying the development of these materials is research into the mechanism of solid-phase reactions as well as into the structure and defects of solids. Organic solids also evoke growing interest.

Production in modern chemical industry is largely based on utilizing the catalytic effect. It is estimated that about 90 percent of its output is obtained by means of catalytic processes. The growth of knowledge about catalysis in interwar years had made possible the establishment of a large-scale industry of nitrogenous compounds, whose availability became a basis for a rapid growth in agricultural production. During the same period also was developed the sulfuric acid industry, which made possible the development of the production of phosphoric fertilizers and many other chemicals. The development of catalytic agents for the cracking of crude petroleum became in the 1930's and 1940's the basis for the growth of the automotive industry and aviation. In the early 1950's, owing to intensive research into oxide catalysts, it became possible to develop active and selective catalysts for oxidizing hydrocarbons with gaseous oxygen, which provided a base of low-cost materials for the production of many plastics and synthetic fibers.

It should be emphasized that the growth of all these new industrial subsectors has been based on the results of longrange and interdisciplinary basic research into catalysis which resulted in, at first, ascertaining the mechanism of many catalytic processes and understanding the mechanism of action of catalysts and methods for their synthesis and, subsequently, in the solution of technological problems relating to the activation of large-scale industrial catalytic processes. Catalytic cracking is among man's most massive technical undertakings, since at present it serves to process more than a billion metric tons of crude petroleum annually.

The abovementioned advances in understanding the structure and properties of chemical bonds, combined with the use of new techniques for investigating solid surfaces, which engendered a new field called the science of surfaces, made possible an atomic-scale identification of catalyticaly active centers as well as the identification of the manner in which these centers transform a substrate molecule into the desired product. The growing potential of computational technology serves to introduce methods of quantum chemistry for the description of elementary stages of catalytic processes, which had previously been beyond the possibilities of science. There is growing integration of traditional fields of chemistry, such as organic chemistry, inorganic chemistry, electrochemistry, structural chemistry, thermodynamics, chemical kinetics, biochemistry, etc., within the interdisciplinary science of catalysis.

The main directions of attack in the world science of catalysis at present are, on the one hand, linked to the requirements of the developing modern theory of catalysis and, on the other, conditioned by the anticipations of trends of economic development and the changing raw materials base. A growing role also is being played by the need to consider environmental factors in economic activity, which will require supplanting many existing technologies with their more energy-conserving counterparts that also entail reduced wastes, as well as developing catalytic processes for eliminating environmental pollution. Of the problems mentioned above, the following receive especially great attention:

-- reactions of CO and CO2 with hydrogen, that is, the processing of gasified coal into hydrocarbons and their derivatives;

-- transformation of discrete functional groups in complex organic molecules in order to synthesize semifinished products used in the production of pharmaceuticals, dyes, household chemicals, crop protectants, etc.;

-- processing, and especially oxidation, of paraffin hydrocarbons in order to broaden the raw materials base of the plastics and synthetic fibers industry;

-- processes of hydrodesulfurization, hydrodeoxidation, hydro-denitrogenation, and demetallization of the products of the processing of crude petroleum and coal;

-- processes of the elimination of impurities from exhaust gases. Here mention should be made in particular of the catalytic purification of automobile exhausts, the elimination of impurities in industrial combustion gases, etc.

The rapid development of the science of catalysis, on the one hand, and the huge advances in the chemistry of natural products, on the other, indicate that enzyme chemistry and enzymatic catalysis are nowadays in the vanguard, being based on the integration of many traditional scientific disciplines.

In modern enzymology the following directions of research are major:

-- acting mechanism of enzymes, particularly of so-called regulating (allosteric) enzymes, i.e., enzymes which explicitly change in conformation and catalytic activity under the influence of various chemical or physical effectors;

-- large-scale production of pure enzymes and their industrial utilization in biotechnology processes;

-- immobilization and structuralization of enzymes with the object of obtaining highly stable preparations for prolonged use;

-- development of synthetic enzymes with highly specific properties and resistance to denaturing factors.

It should be emphasized that, being a major element of molecular biology, enzyme chemistry provides the foundations for constructing enzyme analogues and synthetic enzymes adapted to accelerating and orienting chemical reactions of major importance to the economy. Combining the accomplishments of bioorganic chemistry and enzyme chemistry with the syntheses of structural genes and techniques of genetic engineering may result in simply spectacular biotechnological accomplishments. Major importance also is attached to a greater utilization of natural enzymes in the production and optimal exploitation of biomass, that is, of reproducible natural raw materials. There exist convincing grounds for assuming that biomass may become a significant source of energy, fodder, and food. Hence, the demand for enzymes with a differentiated scope of substrates is huge. At the same time there is a growing need for natural and synthetic effectors of enzymatic reactions, as well as for new enzymatic methods for refining traditional raw materials.

A particularly important role in many biological processes, as well as in many fields of modern technology, is played by the effects occurring at interphase boundaries. The development of new technologies and industrial processes requires exploring the properties of such systems and phenomena as emulsions, foams, liquid films, membranes, aerosols, detergency, wetting, flocculation, dispersion, friction, lubrication, nucleation, sedimentation, and many others. This finds direct application in such important fields of economic activity as ore concentration, environmental protection, or the exploration of new energy sources (water photolysis in strongly dispersed catalytic systems).

The gradients of chemical and electrical potentials existing at interphase boundaries modify the nature of chemical bonds in the molecules present there, endowing these molecules with new interesting properties prompting the appearance of many new effects. These effects are largely decisive to the properties of highly dispersed systems, whose description thus requires allowing for surface parameters. In particular, they determine the behavior of

these systems while under the influence of fields of external forces under dynamic conditions.

At present the development of new measurement techniques, on the one hand, and the possibility of mathematical modeling, afforded by universal computerization, on the other, unlock new vistas for formulating a theory of the stability of colloidal systems and a theory of their coagulation. This principally requires determining the intermolecular forces and the interactions of aggregates, as well as describing transport effects in dispersed systems, which to a large extent determine the behavior of these systems under dynamic conditions.

One of the factors decisive to surface properties, and hence making possible a planned control of the behavior of dispersed systems, is the adsorption of surface-active substances. Hence, research into the synthesis and properties of new surface-active substances is being intensively pursued, with special attention to readily degraded substances, polyfunctional compounds, and substances with particular catalytic properties that are complexing or have a load-transporting capability. Special importance is attached to research into the surface properties of biologically active substances, wherever they are decisive to the mechanism of vital processes in living organism, e.g., to the simulation of biological membranes and of the effects occurring in these membranes, to the coagulation and pepticization of proteins, to micellar catalysis as a model of the action of enzymes, to the conveyance of potential pulses along the membranes, and to many other effects.

A major influence on the course of many processes is exerted by the double electrical layer appearing at interphase boundaries. One way of exploring the structure and properties of these layers is afforded by electrochemical research. Hence also the adsorption of variegated chemical compounds and the formation of layers on liquid and solid electrodes are being intensively investigated. Many studies are devoted to electrochemical reactions, and in particular to electrochemical reactions involving the catalyzing effect of foreign particles (electrocatalysis), as well as to their dependence on the nature and structure of electrodes. This is linked with the work on developing fuel elements as facilities for future utilization of hydrogen as an energy carrier.

In recent times research into the electrochemical behavior of biomolecules as well as into the transport of molecules and ions across various membranes has been pursued with increasing intensity. This research resulted in the development of microelectrodes that find growing application in not only bioelectrochemistry.

For a large number of problems there is a need to describe not only microstates of matter but also macroscopic systems consisting of such a large number of molecules that the thermodynamic functions describing the properties of matter in the mass acquire specific values. The principal thermodynamic functions and their derivatives with respect to parameters of state describe, among other things, such properties of matter as compressibility, density, thermal expandability, range of concentration states, parameters of phase equilibria, thermal properties, thermal effects accompanying chemical

reactions, and equilibrium constants. In recent years thermodynamics research has been focused on the anticipation of thermodynamic properties by means of methods of statistical thermodynamics, description of the thermodynamic properties of real systems, development of measurement techniques with the object of expanding the range of measurements and enhancing their accuracy, and lastly critical analysis of measurement findings as well as of the calculations performed on their basis in the form of ensembles of data on thermodynamic properties with a specified reliability for purposes of basic and applied research. When describing the thermodynamic properties of real system, new equations of state are explored; these equations are, besides, in most cases modifications of known equations, such as the Van der Waals equation, and they lead toward an increasingly better description of selected systems. Or, too, an equation of state is applied only to the gaseous phase, usually in the form of a virial equation, while the properties of condensed phases are described on the basis of the properties of pure substances and of the excess functions of mixtures representing deviations from ideal solutions. The principal trend of research is represented by work on the theory of fluids and by the generation of models serving as a basis for semiempirical equations expressing excess functions.

In addition to the classical models, such as the model of regular fluids, the lattice model of fluids, models of local concentrations, and the model of associated solutions, considerable effort is being expended on the development of so-called models of group participation.

Emphasis should be placed on the great practical importance of thermodynamics research, whose results are indispensable to the design of many technological operations.

A subject of constant interest to chemists is the mechanism of interaction between matter and radiation, which is the subject matter of nuclear and radiation chemistry. Rapid advances are being observed in the application of radioisotopes, radiation techniques, and nano- and picosecond pulsed radiolysis in the research into mechanisms of thermal reactions and for tracing biological processes and also as important tools of medical research. Work to refine separation techniques and explore the properties of actinides and lanthanides and their compounds is being intensively pursued. Radiation technologies are increasingly often employed in industrial practice.

A special position in chemical sciences is occupied by analytic chemistry, since knowledge of the chemical composition of the objects investigated is a point of departure for both scientific research and the control and guidance of production processes in many branches of the economy, such as the raw materials industry, power industry, chemical industry, metal industry, agriculture, medicine, environmental protection, and many others. The current directions of development of analytic chemistry include: exploration of techniques for identifying trace contents of inorganic and organic components in concentrations of the ppb series; chemical speciation, i.e., determination of the chemical forms in which an element is present in the object investigated; remote analysis; and lastly process analysis and control as well as automation of production. This last direction of research is becoming increasingly common in industry and acquires a growing importance in view of

the rising complexity of technological operations, on the one hand, which requires an extremely rigorous maintenance of process parameters, and the growing scale of these operations, on the other, which necessitates their automation and computerization.

Research Priorities in the Chemical Sciences in Poland

When deciding on priority directions of research in this country, allowance has to be made for the following criteria:

-- research should be focused on directions that are consonant with those of the world development of the chemical sciences and decisive to the progress of natural knowledge as a whole;

-- research should concern problems that are of major importance to this country's socioeconomic development;

-- research should be developed in fields which already are represented in Poland by strong scientific schools with acknowledged international authority, or by teams with a proved record of accomplishments significant on an international scale.

In view of the above criteria, it appears expedient to pursue with special intensity the following research directions during the next 15 or so years.

Theoretical chemistry along with broadly conceived structural research. That research nowadays provides a foundation not only for other fields of chemistry but also for many other fields of the natural sciences, such as molecular biology, genetics, immunology, physiology, mineralogy, geology and many others. It appears expedient to develop quantum chemical techniques ab initio, to improve the reliability of semiempirical methods and apply them to important chemical and biochemical problems, to develop simulation methods based on the Monte Carlo method as well as molecular dynamics, and lastly to explore alternative techniques for resolving the intrinsic problem of determining the properties of atoms and molecules. There is a need for a further rapid development of research into the structure of molecules, macromolecules and solids with the aid of varied spectroscopic, electrical, magnetic, and other methods.

Mention is deserved by research into the properties of hydrogen bonds and their role in stabilizing the spatial structure of molecules, conducted at many Polish research centers enjoying high worldwide recognition. The quantum-chemical description of the hydrogen bond is a problem at the cutting edge of theory.

Chemistry of natural products together with organic synthesis. The new stage of development of the biological sciences, characterized by the proliferating utilization of accomplishments of broadly conceived molecular biology in various domains of organismal biology poses to the chemistry of natural products in our country important problems of cognitive and applied research. In particular, it is necessary to conduct research into the stereochemistry and controlled synthesis of peptides and proteins, with special priority to be

given to enzymatic proteins; the stereochemistry of nucleic acids; the stereochemistry of sugars; and the stereochemistry of isoprenoids, alkaloids and antibiotics as well. The organic chemistry of phosphorus, which has an established position in our country, being one of the directions in which this country is a world leader, should be intensively developed, with the research to be focused on stereoselective synthesis of new structures and biologically active systems, important from the standpoint of contemporary biology, agriculture, and medicine., In this context, it should be emphasized that pesticide consumption in Poland is the lowest in Europe, thus constituting a fundamental barrier to an effective increase in agricultural output. Hence there is a need for a rapid intensification of the exploration of new compounds on the basis of knowledge of the biochemistry and physiology of the organisms being combatted, as well as of research into the synthesis of plant growth regulators enhancing the production of sugars, proteins, etc. It can be hoped that genetic engineering, and particularly that of recombined DNA, will be utilized for insect control. An important direction is the application of sulfur compounds in total organic synthesis, as well as research into the stereochemistry and mechanisms of sulfur combination reactions. Research into organosilicon compounds has an established tradition in Poland and should be continued, while research into the organic chemistry of fluorine should be expanded. Emphasis is deserved by the major achievements of the Polish school on the international scale as regards the chemistry of coordination compounds and organometallic compounds. Research in this field should be intensively pursued -- on the one hand, in view of the tremendous importance of these compounds to chemical synthesis, and on the other, as a basis for understanding the mechanism of action of metal enzymes and affording a possibility for synthesizing their models.

Polymer chemistry

Here, special mention should be made of the research into: ionic polymerization and mechanisms of polyreactions of cyclic monomers; the relationship between the molecular and supramolecular structure, on the one hand, and selected (thermal, electrical, mechanical) properties of polymers, on the other, as a basis for the synthesis of polymeric dielectrics and semiconductors; the synthesis, structure and properties of structural polymer plastics, including polymers for medical uses. Considering that the polymers being produced on a large scale in this country, such as polyethylene, polypropylene, vinyl polychloride, polystyrene, and synthetic rubber, are of low quality and the technologies employed need to be modernized, there is an urgent need for focusing research on new solutions for the synthesis of these polymers. In particular, work should be undertaken on the polymerization and copolymerization of dienes in solutions with the object of adding to the varieties of synthetic rubber produced in Poland.

Solid-state physicochemistry as a basis for materials engineering

A major obstacle to modernizing the products of Polish industry, and a reason for their energy- and materials-intensiveness, is the shortage of materials with refined properties and increased parameters. Hence there exists an urgent need to develop rapidly interdisciplinary research by physicists, chemists, metallurgists, ceramicists, materials engineers, etc., into the mechanism of solid-state reactions, the texture and structure of organic and inorganic materials as well as metals, in particular of composites, and the structure of defects and their role in generating various properties of solids. Mastering techniques for the synthesis of new semiconducting and magnetic materials, optical fibers, thin films, superconductors, liquid-crystal materials, etc., is a prerequisite for the proper development of the electronics and computer industries as well as of informatics and many other fields. Of major importance to many basic branches of the national economy, such as the power, chemical, machinery, and aviation industries, as well as to the nuclear power industry, etc., is the development of new structural materials with enhanced resistance to aggressive media at increasingly higher temperatures -- on the one hand, in view of the huge losses inccurred owing to corrosion and on the other, because the development of modern technologies in these industries hinges on improvements in the properties of heat-resistant metallic and ceramic structural materials.

Heterogeneous, homogeneous and enzymatic catalysis

Catalytic research in Poland has expanded broadly in the last 20 years. Research teams and scientific schools that won considerable international renown have emerged. Emphasis is deserved by the marked linkage of research to development work, as evidenced by the fact that about 60 percent of the principal catalysts currently used by chemical industry was developed by domestic research centers. The attainment of marked advances in understanding the catalytic effect will require further expansion of research into the elementary stages of reactions and their kinetics, the nature of active centers and their properties, and the mechanism of their interaction with the reacting molecule. There also exists a need for elucidating the effects of the matrix and of the catalytic-reaction environment on the state and properties of catalysts. Particularly important research topics are the catalytic, heterogeneous and homogeneous reactions of monocarbon compounds such as methane, carbon monoxide, carbon dioxide, and methanol, with the object of utilizing black coal and natural gas as raw materials for the chemical industry; catalytic transformations of hydrocarbons as a source of semifinished chemical products derived from byproduct-coke and petrochemical raw materials; catalytic activation of paraffins, especially on using organometallic and complex-compound catalysts; catalytic and electrocatalytic redox processes; hydrodesulfurization processes; catalysts for the nitrogen industry; and lastly catalysis in environmental protection. As regards enzymatic catalysis, there exists an urgent need for expanding research into the mechanism of action of enzymes, the synthesis, immobilization and structuralization of enzymes with the object of utilizing them in biotechnology processes, and the semisynthetic development of various enzymes with marked specificity of action.

Surface physicochemistry and the chemistry of highly dispersed systems

In view of its great cognitive importance and growing practical importance, the related research has to be intensively pursued. At present in Poland relatively little such research is being done, but the situation is very favorable, because its topics are among the most topical and important to the development of these disciplines, and Polish findings are in the vanguard of the related worldwide research. The Polish findings pertain to transport effects in dispersed systems, theory of interactions in colloidal systems, heterocoagulation research, and theoretical foundations of flotation and electrosorption in highly dispersed systems. In addition, in this country there operate many research teams engaging in the synthesis and investigation of the properties of new surface-active substances. On the other hand, work on the surface chemistry of biologically active substances is done only sporadically; in view of the portentous significance of these substances to basic and applied research, this work should be systematized and intensively pursued. There also exists an urgent need for developing as soon as possible research into the physics and chemistry of solid surfaces, in view of their decisive importance to many other fields of science and technology, such as catalysis, materials engineering, electronics, computer engineering, corrosion, and many others. The research in this domain is being conducted in this country on a very limited scale, chiefly as part of the program for catalysis research.

The work on the structure of the double electrical layer on various electrodes and various electrolytes in anhydrous solvents should be continued and expanded. Modified electrodes serving to expand knowledge of the nature of electrode reactions and accelerate their course with regard to technologically important substances should be worked out. Linked to this problem is the research into electrocatalysis, which should be developed as a possible source of new less energy-intensive and more waste-free technologies for obtaining many important products. The work on the kinetics of electrochemical reactions, chiefly in anhydrous solutions, mixed solvents, and fused salts, should be continued. Research into new power cells, as well as into high-capacity fuel cells, is of promising practical importance.

Chemical Thermodynamics

The currently most important related research being done in this country is of an interdisciplinary nature, utilizing all available and newly developed mensuration techniques and theoretical calculations with a view toward exploring the thermodynamic properties of the principal classes of mixtures and complex systems occurring in practice. This is connected with elucidating the laws linking thermodynamic quantities and phase equilibrium parameters to the structure and interactions of molecules in solutions, as well as with the development of techniques for the forecasting and numerical calculation of the properties of complex systems over a broad range of parameters on the basis of a minimum number of experimental data obtained with the aid of refined measurement methods.

Nuclear and radiation chemistry

In view of the depletion of conventional fuels, nuclear energy will be increasingly important to the Polish power industry. Hence also there exists an urgent need for conducting research into, on the one hand, the chemistry of radioactive elements and, on the other, the chemical affects induced by the action of ionizing radiation on matter. A particularly important role in this research is played by the pulsed radiolysis method. In this country there already exist research centers with experience and considerable accomplishments in this field, and hence it is expedient to further develop research methods and apply them to investigating primary and secondary processes in model systems, with allowance for polymers and biological compounds. Exploration of the kinetics and mechanism of the reactions of the ionic and radical products and excited molecules generated during the radiolysis of chemical systems in the gaseous phase is important not only directly to elucidating the effects of ionizing radiation but also to understanding the general laws governing the reactivity of chemical molecules.

Chemistry of metals with special consideration of the synthesis of complex compounds and organometallic compounds.

The Polish school of the chemistry of coordination compounds has a record of significant accomplishments on the international scale. Research in this field should be further intensively pursued in the direction of syntheses of new compounds, such as the complex compounds and organometallic compounds of metals with unusual degrees of oxidation or unusual ligands, as well as syntheses of new materials (e.g., conductors, magnetic materials, "klasters," etc.). This research is at the same time of tremendous importance by providing a basis for, on the one hand, developing the theory of chemical bonds and, on the other, understanding the action of metal enzymes and providing a possibility for synthesizing their models. In view of the rich reserves of metal ores in Poland, research into the development and properties of metals and their inorganic compounds, particularly of rare metals, should also be continued and expanded so as to broaden the possibilities for their increasingly better utilization.

Conditions for the Development of Chemical Research in Poland

The pursuit of the abovementioned directions of the development of chemistry in Poland requires meeting three basic conditions, namely, an intensive development of:

-- techniques of chemical analysis;

-- informatics;

-- facilities.

The development of analytic chemistry should primarily comprise methods for trace analysis, chemical speciation, and identification of the spatial distribution of constituents (analysis of solid surfaces and surface layers). The obligations resting on the chemical sciences as regards the government

programs for improving the quality and effectiveness of production require that rapid advances be made in the automation and computerization of the techniques of analytic chemistry.

As regards informatics, meeting the needs of the chemical sciences requires implementing the following tasks:

-- development and operation of data acquisition terminals and microcomputers for automating controlled experiments and technological process contro. Of major importance to industrial applications are hierarchic data acquisition systems with an expanded procedure for prioritization, warning, etc., while as regards research applications, programmable activation terminals assure greater flexibility and easier adaptation to various tasks;

-- development of computer networks with at least a national scope as well as of central data banks (e.g., patent, literature, technical-economic, etc.) adapted for a rapid on-line information retrieval. Of special importance for research purposes are catalogs of scientific literature, spectroscopic data, properties of chemical compounds, structural data, etc.;

-- broadening the use of numerical techniques for data processing as well as for purposes of chemical engineering. For many technological problems, computers of medium computational capacity are adequate so long as they are broadly programmed;

-- training of personnel capable of fully exploiting the possibilities afforded by the development of informatics.

Of major importance to providing the conditions for accomplishing the research goals discussed above is equipping the research centers with modern research facilities. The present state of the facilities of research centers in Poland is alarming. They have not been renewed for many years and they are worn, and moreover they increasingly lag behind the huge and extremely rapid worldwide advances in facilities for scientific research. There arises a fundamental discrepancy between the equipment and the creative potential of the existing science personnel, which threatens the formation of a gap between the level of world science and science in Poland. The lack of up-to-date x-ray diffractometers, high-discrimination electronmicroscopes, ESCA and Auger spectrometers, unique equipment for investigating solid surfaces (such as slow-electron diffractometers, electron energy-loss spectrometers, ion-scattering spectrometers), mass spectrometers for various purposes, Fourier-transform infrared spectrometers, special equipment for research employing isotopic tracers, and many other devices, impedes the initiation of many important and ambitious research projects that often are decisive to progress in various fields of the natural sciences. Hence also the renovation and complementation of research facilities must be considered among the most important and urgent needs of Polish science. This must take place in various ways, to wit, through the allocation of substantial foreign-exchange subsidies for the acquisition of foreign equipment, expansion of the production of domestic equipment for the purposes of scientific research, and a more efficient use of the available equipment. Here there is a need for increasing by a factor of several times the expenditures on imports alone, and

that mostly from the dollar zone, because the CEMA countries are not yet self-sufficient in this field. The domestic output of precision equipment and instruments also is extremely modest, and what there is manufactured is largely destined for export, thus complicating their acquisition by domestic users.

In particular, attempts should be undertaken to modernize the facilities of the already existing institutional laboratories. In the course of the more than 10 years of operation of these laboratories it turned out that this solution allows an effective utilization of unique scientific-research equipment and assures access to that equipment for large numbers of science personnel engaging in research both at the laboratories of a given research center and at laboratories located elsewhere in this country.

Academy Activities in 1984

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[Article by Zdzislaw Kaczmarek, Active Member, Polish Academy of Sciences: "Activities of the Polish Academy of Sciences in 1984 in Relation to the Situation in This Country and in Science" (Footnote) (Text of paper by Scientific Secretary of the PAN [Polish Academy of Sciences] Prof Dr Habilitatus Zdzislaw Kaczmarek, presented at the 62nd Session of the PAN General Assembly on 31 May 1985 in Warsaw)]

[Text] The Polish Academy of Sciences is the leading or, as put in the decree on the PAN, supreme scientific institution, but its potential accounts for only a small part of Polish science. As for Polish science itself, it is only a fragment of the socioeconomic structures of our fatherland, a part of the complex and difficult Polish reality. Hence, a report on the PAN's activities should be considered against the broader background of the problems and science policy of this country.

In all countries with a medium or high degree of development, the growing importance of science and technology progress to the solution of the problems limiting the further development of mankind is championed. Poland is not the only country to experience difficulties. Scientists and politicians in many countries are discussing the possibilities for surmounting present and potential barriers to development. During a meeting in June 1985 of the party and state leaderships of the CEMA member countries was formulated the thesis of the role of science and technology as a factor decisive to the further development of the socialist community. Similarly, last year there was published a document hundreds of pages thick relating to a conference of the ministers responsible for science policy in 24 developed capitalist countries belonging to the OECD, whose conclusions coincided with those of the CEMA Conference.

It is worth noting that the directions of the "main strike" representing the basis for science policy in both competing blocs of countries are convergent. These directions include:

-- spread of informatics and electronics throughout the economy and other domains of social life;

-- exploration of new materials as well as of marterials- and energy-conserving production techniques;

-- development of molecular biology and its applications in industrial technologies and in genetics;

-- exploration of technical solutions serving to curtail the degradation of natural environment.

There is no doubt either that a growing part of the world's scientific potential is becoming committed to the solution of military problems. Modern science is not, unfortunately, neutral toward the various economic and political conflicts dividing the world. What is more, with a growing frequency it provides a major basis for these conflicts.

Poland's science policy is undoubtedly influenced by the abovementioned world tendencies, but its particular nature is determined by specific Polish problems and difficulties. In general, industrial organizations in this country are not interested in new solutions incorporating the latest peak achievements of world technology, and they expect from research institutions assistance in overcoming various difficulties associated with the production of materials, equipment and products at the technological level of the 1970's. A characteristic example is the need to develop substitutes for materials and components that used to be imported from the countries of the dollar zone. Given this situation, the topics of applied research and development work in Poland are and have to be rather detached from the mainstream of world science and technology. As for basic research, it is often undertaken in isolation from economic realities, and the prospects for its social usefulness are uncertain. The resulting dilemmas, when combined with the shortage of resources for the development of research facilities, are a source of anxiety and frustration to the science community.

It is thus a behest of the moment to formulate lucid principles of Poland's science policy, such that this policy would allow for a rational meshing of present-day needs with the prospects for this country's social and economic development. Without a longrange strategy, and without a feeling of social usefulness, science cannot develop. The formulation of assumptions of such a policy has been assisted by the preparations for the Third Congress of Polish Science initiated in 1984, and primarily by the scientific committees and departments of the PAN under the direction of the Congress Organizing Committee. The related discussions last year have resulted in, among other things, the publication of "Theses for the Third Congress of Polish Science," disseminated among the science community early this year.

Important events in the science policy of our country were the meetings between the PAN leadership and the chairman of the Council of Ministers and the accompanying representatives of the party and the allied political parties, as well as of members of the government. During these meetings, which took place in April 1984 and in May 1985, the following principal problems of Poland's science policy were discussed:

-- principles for selection of main development trends of science, inclusive of basic research;

-- relationship between the programming of scientific reesearch and national development planning;

-- outlays on research activity, equipping of research laboratories, and improvements in the material situation of science personnel;

-- publishing activities;
-- foreign scientific cooperation;

-- organizational structures responsible for shaping and implementing the state's science policy.

The decisions taken during these meetings were reflected in the government schedules of task implementation and are regularly monitored.

The national research program for 1984 was implemented in the form of targeted government, key, interministerial and ministry programs, established at the beginning of the 5-year period. The structure of this program did not change markedly last year, although, of course, the coordinators and their advisory teams verified thoroughly specific tasks. This also applies to the interministerial programs for basic research, which are under the special supervision of interministerial basic research commissions, whose chairpersons or representatives may want to offer their comments during the discussion. The so-called government orders [contracts] in the field of science and technology, whose paramount purpose was to accelerate the process of the practical application of research findings in the economy, have become a new structural element in the planning and coordination of research.

Pursuant to a government decision, the national research program is currently being evaluated by the ministry heads and the PAN Scientific Secretariat, with the participation of interministerial commissions. The results of these studies will be submitted to the Council of Ministers sometime in mid-year. It has to be emphasized, though, that the complete fulfillment of this program can be assessed only after the end of the 5-year period, for which the goals of particular programs were outlined.

At the institutions of higher education and laboratories of the PAN research projects that often are of major cognitive importance are being undertaken outside the framework of central programs, with the resources of the scientific institutions themselves. Unfortunately, aside from the Polish Academy of Sciences, research sectors lack a system for gathering information on the results of that research. It is believed, though, that the most valuable of these projects find their way to national Polish science periodicals and thus can face the court of public opinion of the entire science community. Research initiatives of this kind, undertaken by individual scientists or science teams, should be within reasonable limits financially supported by the state. The Polish Academy of Science allocates one-seventh of its budget for these purposes.

As we know well, modern science requires substantial financial outlays. The material situation of Polish science unfortunately remains very difficult. Poland's share in the R&D spending of CEMA countries in 1984 was about 2 percent, although its population accounts for about 10 percent of the population of these countries. In relation to world spending on research and technology activities, our share does not exceed 0.4 percent.

In 1984 R&D spending in Poland amounted to 94.8 billion zloty, or about 1.34 percent of generated national income. Compared with the preceding year, this was an increase of 41 percent. But I wish to emphasize that a much higher amount, as much as 153.3 billion zloty, had been at the disposal of the supreme bodies of state administration and enterprise managements. Unfortunately, a considerable part of these funds remained unutilized in the Technical-Economic Advancement Fund accounts kept by economic organizations. This is a particularly disturbing phenomenon, as we are observing a steady growth in the size of these unutilized funds. As of the end of December 1981, their total amounted to 4.1 billion zloty, whereas at the end of December 1982 it was 13.1 billion zloty, and at the end of 1984, as much as 58.5 billion zloty.

We drew attention to this menacing trend during the last meeting between the PAN leadership and the chairman of the Council of Ministers. We stressed that, to be sure, the 1985 plan assumes a further substantial increase in the funding of scientific research at the level of 1.85 percent of national income, but the science community is bound to feel worried about the scope and manner of utilization of these funds. I wish to emphasize that the Polish Academy of Sciences utilizes in full the funds allocated to it for research activities.

In view of the interest of the members of the General Assembly in the activities of scientific institutions covering the entire domain of science, allow me to advise that the breakdown of outlays among these institutions was as follows:

PAN	9 %
Higher educational institutions	16 %
Ministry research centers	53 %
Ministry development centers	22 %

It ensues from this breakdown that the share of the PAN and its laboratories in these outlays still is relatively low, even though it has proportionately increased in the 1980's compared with the 1970's.

On presenting to the government leadership the financial situation of science we pointed to, both in 1984 and in 1985, special needs, including the need for foreign exchange, ensuing from the poor facilities of experimental laboratories and the radical shortcomings as regards publishing facilities. We documented these needs with detailed studies, including a study by the Committee for Metrology and Science Equipment.

The human resources of Polish science are impressive. With respect to academic personnel alone it can be stated that in 1984 Polish science had at its

disposal 11,900 professors and docents (11,700 in 1983) and 54,000 adjunct professors and assistant professors (53,800 in 1983). Seventy percent of the nation's science personnel work at institutions of higher education. Thus, these institutions shoulder a particularly great responsibility for the development of science and the technical level of the national economy.

Science personnel cooperate with a large force of engineers, technicians and blue-collar workers employed in scientific institutes and higher educational institutions. Without that force it is impossible to conduct at an adequately high level research into the engineering, exact, agricultural, etc., sciences. Yet, the numbers of engineers, technicians and blue-collar workers at research centers are declining. What is more, it is the most valuable of these people who are leaving for industry, owing to salary considerations. This situation adversely influences the effectiveness of cooperation between science and the national economy.

Attention should also be drawn to the decline in recent years in the number of doctoral and habilitated doctoral degrees conferred, as well as in the number of extraordinary professorships conferred. This decline is particularly notable in 1984. This is illustrated by the table below.

Period	PhD's	Hab PhD's	Extraord. Prof's
1976-1980 (yearly average)	3,767	588	335
1981-1984 (yearly average)	2,936	515	287
1984	2,538	508	284

A particularly substantial decline in the number of doctoral degrees conferred occurred in the engineering sciences -- by 40 percent in 1984 compared with the yearly average for 1976-1980. This is an unfavorable trend, particularly when we consider the need to expand the scientific disciplines that are to be responsible to a greater degree for meeting the needs of industry.

For several years now the PAN leadership has been drawing the attention of the state authorities to the difficult material situation of science personnel. We have reported on our efforts to the members of the General Assembly. Compared with 1982, when the situation was particularly unfavorable, this situation has improved somewhat at present, although of a certainty it still remains a source of discontent and tensions within the science community.

For the first time since 1980, monthly pay in the science and technology sector [of the economy] exceeded in 1984 by 1.5 percent the nationwide average pay. Compared with 1982, in the last 2 years nominal wages in this sector of the economy increased by 66 percent, and real wages, with allowance for the rise in the cost of living, by 17 percent. At the same time, a growing differentiation of salaries among research centers and individual employees can be observed. This ensues from the financial autonomy of the institutes and the endowment of their directors with the power to determine salaries

depending on the financial situation of the institute. This trend also applies to PAN institutes and laboratories, at which average [monthly] wage varies markedly, ranging from about 13,000 zloty to 21,000 zloty.

In the last few days the Council of Ministers has adopted a number of ordinances concerning changes in the rules for the remuneration of the personnel of higher educational institutions and research centers. With respect to PAN branches and ministry institutes, the new rules provide primarily for increasing base pay and regular pay allowances while at the same time reducing the share of periodic bonuses in employee pay. However, institute directors shall not be bound by these rules insofar as determining the overall bonus fund or the size of the individual bonuses is concerned.

It is assumed that nominal wages at PAN branches will increase by about 23-24 percent in 1985, i.e., will be roughly 10 percent higher than the wage increase assumed in the Central Annual Plan for the economy as a whole.

Of major importance to the state's future science policy is the decision to establish the Committee for Science and Technology Progress [KNiPT] as well as the Office for Science and Technology Progress and Applications -- a decision taken in December 1984 following lengthy and not emotionless discussions. The PAN leadership has long been expressing itself in favor of solutions promoting an integrated state policy on science and technology that would be free of the burden of parochial interests. We view the KNiPT, whose membership includes, besides, some 15 PAN members, as a body promoting the pursuit of such a policy. Discussion on the tasks of this Committee and of other supremse state bodies is still continuing. I wish to express my conviction that this discussion will lead to a precise division of tasks and responsibility for science and technology policy and make possible cooperation among interested offices and institutions on the basis of equal partners. We wish to help identify the solutions that best promote this country's interests. We are also interested in shortening the period of transition from old to new organizational forms.

During its meeting last year with the chairman of the Council of Ministers the leadership of the PAN submitted a proposal for establishing a Council for Basic Research as a state body for improving the coordination of that research and providing the funds it needs. Opinions on this proposal continue to be divided. We are at present exploring, jointly with the heads of the Ministry of Science and Higher Education, interim and longrange organizational solutions that would serve to:

-- assure concerted cooperation among the higher educational institutions, PAN institutes, and other institutes interested in basic research;

-- link the basic research program to the longrange aims of Poland's socio-economic policy;

-- win proper recognition, in terms of the indispensable funding as well, of the importance of basic research, within the framework of a KNiPT-evolved state plan for the development of science and technology in this country.

I wish again to stress that, by virtue of its legal duties, traditions, organizational structure, and international connections, the Polish Academy of Sciences bears a special responsibility for the selection of the directions and level of cognitive research. We give considerable credit to the Ministry of Science and Higher Education and its subordinate higher educational institutions for their cooperation so far in this field.

I also wish to present in a summary form certain information contained in the report on the Academy's activities in 1984 whose copies have been distributed to day to members of the General Assembly, without going into much detail about the nature of that document.

The Academy's budget was increased by 23 percent in 1984 compared with 1983, and the outlays on research at the Academy's institutes have been increased to the same extent. Following is a breakdown of this funding among discrete fields of research: social sciences, 12 percent; biological sciences, 16 percent; exact sciences, mathematics, physics, chemistry, 27 percent; engineering sciences, 21 percent; agricultural sciences, 6 percent; medical sciences, 7 percent; earth sciences, 11 percent.

At the Academy's Scientific Secretariat the conviction is gaining ground that the share of the biological sciences in the PAN's research outlays is inadequate. I believe that, when drafting the program for the next 5-year period, this question will require a detailed analysis and, of a certainty, a revision of these proportions.

The personnel of the Academy has declined by 5 percent compared with 1983. This is partially due to the efforts of the heads of its institutes to budget their funds so as to increase staff salaries rather than to expand staffs. As in science as a whole, at the Academy this personnel decline concerns chiefly engineers, technicians, and administrative employees, whereas science personnel itself has for several years now been stable numerically. Emoluments at the institutes of the Polish Academy of Science have been raised to the same extent as elsewhere in science -- by 22 percent.

As for the facilities of the PAN institutes, we consider them to be definitely unsatisfactory. Reports which we submitted to the state leadership demonstrate that these facilities are below average for Polish science as a whole. In particular, the wear on scientific equipment at the Academy is extremely high.

The activities of the Academy's institutes last year were focused on the targeted key and interministerial programs established at the beginning of the present 5-year period which I have repeatedly discussed at sessions of the General Assembly. Interministerial commissions have proposed, and the Scientific Secretariat has considered, slight thematic modifications of discrete programs as well as, of course, the attendant modifications of financial outlays.

The report distributed to the members provides a fairly detailed picture of the results achieved each year with respect to every individual such program. I would rather refrain from an analysis and evaluation of these results here, because this would involve a hazardous division into more important and less

important projects, which, when comparing results attained in different scientific disciplines, is immeasurably difficult, if at all possible. Besides, the members of the General Assembly can themselves, on the basis of the copies of the document distributed among them, assess -- especially as regards the disciplines which professionally concern them most -- the value of the research projects represented in the report by coordinators and institutes. I wish merely once more to offer the reminder that the Academy is obligated to submit to the Council of Ministers by mid-June of this year an assessment of the course of the fulfillment of the program for basic research. Work on this task is currently in its final stage.

The year 1984 -- the first year of the new official term of the Academy's officers -- was a period of formation of new structures within scientific committees. Altogether, 112 scientific committees were appointed -- three more than during the previous official term -- and their membership is somewhat higher, 5,400 persons. As before, a dominant share of membership in the PAN's science committees, 57 percent, belongs to the faculty of higher educational institutions. PAN personnel account for 18 percent, and personnel of other institutions in this country, 25 percent.

The scientific committees have been focusing their attention on two other kinds of activity in addition to organizational matters connected with the commencement of their official terms. First, the preparations for the Third Congress of Polish Science, as part of which, during the first stage, the committees analyzed and evaluated the implementation of the resolutions of the Second Congress of Polish Science. On this basis, PAN departments next prepared overall reviews. As the next stage of their preparations for the Third Congress, the scientific committees have been working on the proportions among main tasks of science in given disciplines for the period until the end of this century. The second kind of added activity of the Academy's scientific committees has been has been their advisory work, which is of great importance to the Sejm as well as to discrete high-level bodies of state administration.

I wish to dwell somewhat on problems of the PAN's international cooperation. The Academy's policy in this field is subordinated to the goals of, first, utilizing scientific cooperation with foreign research centers in order to strengthen Poland`s science potential and implement the national research program, and, second, incresing the degree and scope of cooperation with the scientific institutions of the socialist countries. I wish to advise the members of the General Assembly that, in the course of the numerous talks conducted recently with the object of accomplishing that second goal, we met with considerable goodwill and understanding of our needs on the part of our partners. This was reflected in particular during last year's December conference in Warsaw of the Polish and USSR leaderships responsible for science and technology, as well as during our meetings with the leadership of the Soviet Academy of Sciences and other academies.

The numbers of PAN personnel participating in international exchanges has been considerable. In 1984 we attained the level of the late 1970's, the highest in the Academy's history. Last year, more than 4,600 Academy science personnel traveled abroad, with 2,500 of this number going to the socialist

countries. At the same time, a substantial number of foreign science personnel, namely, more than 4,300 persons, came to the Academy.

With regard to international cooperation, I wish to point to the growth in recent years of a disturbing trend, namely, the tendency to remain abroad displayed by employees dispatched there on official trips for longer or shorter periods of time. I shall not enlarge on this topic, which requires a thorough analysis, but this trend is beginning -- at least in certain domains of science, at certain institutes -- to affect tangibly the status of our human resources.

The May session of the General Assembly is traditionally devoted to discussing last year's results, this also being the subject of the report on the activities of the Polish Academy of Sciences. To conclude my address, I wish to stress the special importance of the work being done this year. First, this is the year during which the research program for the next 5-year period is being shaped. Jointly with the Committee for Science and Technology Progress, the Ministry of Science and Higher Education, and the Office of Science and Technology Progress and Applications, we have been drafting proposals for the 5-year plan. These proposals have been, already since the middle of last year, of interest to the institutes, committees, Scientific Secretariat, and Presidium of the PAN as well. Secondly, this is the year in which the program for the nation's development will be determined for a period of 5 or perhaps more years ahead. The barriers mentioned by the chairman of the Council of Ministers during his last meeting with the Academy's leadership must be to a large extent abolished through the participation of our community, the participation of Polish science and Polish technology. We share the responsibility for evolving that plan as well. During a meeting at the PAN the chairman of the Planning Commission emphasized that the science and technology community submits to the Planning Commission many questions or documents stating that it is not possible under the present conditions to attain more efficient and effective solutions in the national economy. I have questioned this position during the session. A question that arises is: to what extent will we respond, through our current and future activities, to the basic problems facing Poland and to the challenge posed to us by the modern world. I believe that this question, too, merits discussion at today's session of the General Assembly.

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[Article by Adam Urbanek, Active Member of the PAN: "Cognitive and Applied Significance of Modern Biological Sciences" (Footnote) (Review paper by Prof Dr A. Urbanek, Secretary of Department II, Biological Sciences, PAN [Polish Academy of Sciences, prepared on the basis of analytic and assessment studies of the Department's scientific committees following a discussion at the April 1985 plenary session of the Department in Poznan)

[Text] The claim that modern biology has entered upon the road of a scientific revolution has by now become a truism ccomplicating a comprehensive approach to the complex whole of the genuinely extraordinary cognitive and practical accomplishments and prospects that have arisen as a result of the dynamic development of the biological sciences in the last 25 years.

The mechanism prompting the revolutionary advances of biology turned out to be the integration of genetics with biochemistry in both theory and practice, which has led to the rise of molecular biology. This new discipline has produced far-reaching changes in the basic biological concepts (by, among other things, introducing and redefining the concept of genetic information) and, as a result, it led to the invasion of molecular engineering into diverse fields of biological research, inclusive of systematics, population genetics, and evolutionary biology, along with reorientation toward microorganism research, especially into the peculiar bacterium-phage system. Furthermore, in the last 10 years there has occurred yet another shift of molecular biology from prokaryotic cells into the genetic cells and apparatus of higher plant and animal organisms.

Owing to the unexpectedly rapid advances of the molecular biology, research into the structure and functions of the genetic apparatus has opened up the possibility of creating new genetic systems not existing in nature by means of in vitro DNA recombination and gene cloning in microorganism cells. This is a program of genetic engineering that utilizes the possibilities for transferring genetic material between distant groups of organisms. In recent years this program has been complemented with a broader formula of biotechnology: the utilization of natural and artificial biological systems, as well as of the mechanisms of the processes occurring in them, in medicine, industry, agriculture, and environmental protection. The slogan, if not the magic word, "biotechnology," proved in this connection to be unusually popular, and integrated research and utilitarian programs envisaging radical

changes in many fields of industrial technology have arisen in many countries. In this connection, biotechnology encompasses both molecular engineering (e.g., enzymatic engineering) and cell engineering. The latter can apply to both pro- and eukaryotic cells and encompasses, among other things, techniques for the fusion and hybridization of cells as well as mutagenesis and the selection of new strains. Thus a new situation has arisen in biology, different from the situation applying at the time of the Second Congress of Polish Science.

The only growth pace comparable with this breathtaking development of molecular biology and derivative fields in the world is that of the development of environmental biology in the last 20 years. This term is used to define a complex whole of disciplines that primarily comprise ecology, usually construed as the science of the structure and functioning of living nature, and the scientific foundations for the protection of nature and natural environment. Modern ecology is primarily concerned with research into large systems, defined as physiocenoses or "ecological landscapes." They comprise series of ecosystems participating in the creation of these landscapes, and their functioning, energy flux and matter circulation, and the relationships among their biological components, are the subjects of research. In view of the dramatic rise in environmental threats owing to man's activity, throughout the world, there is a growing number of studies of the effect of anthropopressure and the nature of precisely those ecological systems that are markedly influenced by industrial and communal pollution. Against the background of the growing threat represented to the environment by the rise of the industrial civilization, ecology has become the basis for a new attitude of man toward nature; on this basis, new philosophical, attitudinal, and political-legal concepts are arising. Environmental biology provides the strategic foundations for a rational utilization and protection of the environment, for regular monitoring of its state and of the extent of the threat to it (ecological monitoring), and for the principles of restoring destroyed environments.

Thus, the development trends of biology in modern world science are unusually polarized. The most attention and the largest human and financial resources have been committed to the solution of problems relating to two extreme levels of the organization of biological systems -- molecular and large ecological systems, which besides are becoming increasingly close on the global scale. There explicitly exists a major consensus of views that research into these extreme levels of organization is the most productive cognitively and most promising from the standpoint of practice.

A research program concerned solely with these two mighty trends of world science would soon lead to a dramatic schism in biology. The indispensable unity of the biological sciences is assured by those of their disciplines that are concerned with processes occurring at all levels of the organization of living systems, that is, both molecular and organismal processes as well as population-species processes and those reflected in changes in large ecological systems and the entire biosphere. Such processes include evolution, and evolutionary theories are the most integrative biological theories.

Present-day evolutionism is developing with unusual vigor, although currently it is not as coherent a domain as it had been 25 years ago, when it was dominated almost entirely by one theory, namely, the general theory of evolution.

The discovery of a new aspect of evolutionary changes -- molecular evolution -- as well as certain unusual parameters of evolutionary processes at the molecular level, a new view of speciation processes, and in particular a new view of the explored domain of the so-called macroevolution, and the discovery of the feasibility of transfer of genetic material between phylogenetic lines (so-called horizontal transfer), have engendered a surge of criticism of modern neo-Darwinism. This criticism most often results in undermining or weakening the traditional conceptual schemas without replacing them with equally lucid and operative statements. Modern evolutionary biology exists in the stage of mastering new fields and aspects of evolutionary processes which have appeared as a result of scientific advances, and it may be that the conceptual apparatus of the general theory of evolution will prove inadequate for this purpose. It should be particularly emphasized, however, that the advances in molecular biology and genetic engineering have not undermined the foundations of evolutionary biology; on the contrary, these advances themselves require employing evolutionary concepts in order to be understood. As for the rising divergences between the molecular-genetic, phenotypic-taxonomic and ecological views of evolution, these may perhaps serve to formulate a new paradigm.

Modern evolutionism plays in this connection the role of a connecting agent linking seemingly distant disciplines; techniques of biochemistry, genetics, systematics, morphology, paleontology, and ecology are often concurrently employed to solve a single evolutionary problems (e.g., the rise of the species).

Evolutionary biology provides an example demonstrating that the solution of biological problems requires cooperation among and across both modern and classical natural disciplines. The latter, besides, also are undergoing modernization.

The Role of Biology as a Contributor to Culture and Philosophy

The accomplishments of modern biology in elucidating the structure and functions of living organisms and tracing their origins and development are among the most outstanding intellectual achievements of the 20th century. Biology is, next to physics, increasingly often becoming a basis for philosophical reflections on the foundations of modern natural sciences, while biological problems attract the growing interest of mathematicians, physicists, and chemists. Interdisciplinary fields of science such as bioorganic chemistry, which combines the problems of organic chemistry, biochemistry, and molecular biology into a single research program, are arising.

For all that, biology retains many specific features ensuing from, among other things, the uniqueness or extraordinary rarity of life in the Universe, as well as from the fact that man belongs in the world of living organisms. The

retention of a close emotional tie between modern civilized man and the biosphere, which E. O. Wilson defines by the term 'biophilia,' imposes special importance on research into animate nature. By studying "lower beings," man also learns much about himself. Biology can also contribute to a better understanding of biological factors in the individual and collective life of mankind. Questions of the origin of life, the causes and historical course of development of organisms (evolution), or the origin of man, have been not only important biological problems but also the subject of great philosophical and attitudinal controversies which, as it turns out, have in no way ceased to be topical. It is an indispensable duty of the biologist community in Poland to inform the broad public about the nature and ways of scientific cognition, the value of systematic and objective analysis of phenomena and occurrences to the scientist and to the entire society, and the significance of scientific facts and theories.

The tumultuous course of the political-economic crisis in Poland has been pregnant in certain positive and negative social consequences. The latter include the rise of irrational attitudes and an undermined trust in science, as often reflected in superficial judgments and unjust appraisals of the role of scientific cognition to the culture of modern societies. Biology, like any other science, was created by men and should return to men as a component of culture and enlightenment and as a cognitive and practical value, and the search for scientific truth should be recognized as a high ethical value. The rise of a "mistrust gap" between the scientist community and the society should be energetically prevented, and work should be done to restore the public's understanding of the role of science in the modern world. The scientist community cannot relinquish its right to influence the society, and it must act independently as a factor shaping public opinion on fundamental questions relating to the scientific world outlook and social issues. Such an active attitude of the scientist community is an indispensable ingredient of the formula for pluralism in our society.

Implementation of Resolutions of the Second Congress of Polish Science in the Presence of the Socioeconomic Crisis

The Second Congress of Polish Science has in principle defined correctly the development priorities of Polish biology, on pointing to the special importance of molecular biology, environmental biology and evolutionary and theoretical biology. It justly stressed the tremendous cognitive role of biology, the growing prospects for its practical applications, and its great importance as a cultural and world-outlook factor. It also justly recognized the great role of computers and electronics to many fields of biology. It defined modern biology as a science existing in a revolutionary stage.

These declarations of the Second Congress of Polish Science, outlining the general development concepts and structure of research programs in the field of biology, have retained considerable topicality, and their validity has been demonstrated by the unfolding of events.

The following factors account for the positive role of the Second Congress of Polish Science, whose evaluation is woven like a thread in the studies by a majority of the committees:

-- accumulation of materials conditioning the longrange development of disciplines and a correct and still topical selection of thematic proportions in successive research programs;

-- placement of Congress resolutions in the focus of attention of scientific opinion and the subsequent energization of discrete disciplines;

-- partial implementation of important scientific goals;

-- correct articulation of postulates concerning the material development of science.

The growing economic difficulties starting in 1976 have, however, resulted in that the development assumptions for biological disciplines presented at the Second Congress of Polish Science, which were consonant with the worldwide trends, have not materialized as expected in Poland. A deep chasm formed between the conceptual value of the [assumptions of the] Second Congress of Polish Science and their consequences. In the meantime, though, broadly conceived biological sciences have made tremendous strides in the world. This has resulted in increasing during the last 10 years the gap between Polish biology and the biology being developed in the world's leading countries. For this reason, assessments of the implementation of the resolutions of the Second Congress of Polish Science, as contained in studies by a majority of the scientific committees, are immeasurably critical in tone.

Economic difficulties were reflected in the failure to fulfill many postulates of the Second Congress of Polish Science as regards the acquisition of at least minimum equipment needed for research and instructional purposes, and they have completely halted the implementation of the program for construction projects. This has aggravated the already considerable space problems of several of our principal institutes and prevented the establishment of the Institute of Microbiology and Virology, PAN.

These effects became intensified in the early 1980's, causing, among other things, a breakdown in the supplies of materials and reagents, as well as interruptions in subscriptions to periodicals and, generally speaking, in the influx of scientific literature. The shortage of foreign exchange for the acquisition of spare parts and repair of existing equipment has led to a marked decapitalization of previously acquired facilities, while the total cessation of imports was reflected in the aging of existing facilities.

These effects have been accompanied by a deterioration in the material situation of scientists, and this situation has engendered moods of pessimism and irritation.

The above objective factors necessitated revising part of research plans and abandoning the most ambitious goals and replacing them with a less original but more feasible program. Part of the research programs, especially in experimental biology, was implemented through a kind of "export," i.e., by performing the principal part of research during stays at foreign research centers and completing and complementing it upon return to this country. This

was assisted by the intensive research exchange maintained despite the adverse situation. This solution, justified by the logic of events, displays many positive features, such as the always valuable maintenance of contacts with the leading centers of world science and the maintenance of a high level of science personnel and its ability to employ the latest research techniques.

It would be improper, however, to overlook certain disturbing aspects of such a division of labor. As a side effect, this results in a marked depreciation of domestic research facilities and the abandonment of certain research that could be done in this country by the dint of extra effort and ingenuity, but which is being postponed while waiting for a general normalization or... for another trip abroad. The tendency [of Polish scientists] to prolong their stays abroad [their] fairly frequent decisions to remain abroad are disturbing.

As the economic situation of this country becomes normalized and the financial status of science as well as the material situation of scientists improve, it is necessary to renovate science facilities and elevate their level to that serving to implement the principal part of the national research programs, with only special programs requiring the most up-to-date and domestically unavailable facilities being reserved for foreign trips. A prerequisite for the success of such a program for surmounting the crisis is a substantial improvement in the material situation of science personnel as well as the return to a consistent implementation of the program for construction and equipment investments, these being the premises for normalization and renewal.

The economic crisis in Poland has also produced a distinctive situation in the field of demand for technological innovations, a situation that is not free of contradictions. During the period of economic difficulties, it is natural of the authorities to expect greater assistance from the science community, as reflected in, among other things, development of new technologies. At the same time, though, certain branches of industry do not anticipate, in view of these same economic difficulties, introducing new technologies. To be sure, despite such a situation science in Poland does not face that danger of commercialization which increasingly menaces science in the leading countries of the West, and neither do we in this country have any reason for setting up an alternative science, but it can be judged that we are paying too high a price for this forced "purity" of our science. The elaboration of an effective program for the relationship between science and the economy requires a thorough analysis of the possibilities of both partners, which is something that has not yet been achieved so far as the biological sciences are concerned. Department I of the PAN has initiated a number of proposals in this respect -- the Central R&D Program -- which comprise offers of new biotechnologies as well as of many government orders.

The economic crisis and the drastic decline in industrial potential have produced far-reaching effects on environmental protection. It did not prove possible, contrary to the expectations, to halt the ongoing degradation of environment by industrial, agricultural and urban pollution. There is also a lack of instances of effective large-scale environmental renewal. This engenders a mood of discouragement and lack of faith. To be sure, longrange scientific programs in ecology and natural protection have provided the

scientific foundations for identifying the origins, scale and consequences of environmental threats. But in no case can environmental biology substitute for industry or the economy as regards curtailing or eliminating environmental pollution and environmental menaces. Such an aim can be accomplished only by means of technical methods that are mostly already well known and applied worldwide, within the framework of a well-conceived investment program.

A characteristic feature of biology is the rapidly growing intricacy of research equipment and the increasing dependence of the biologist on his research tools as a factor decisive to the initiation and execution of research. This applies in particular to molecular biology and several other leading fields of experimental biology.

The successes of molecular biology are based on an unprecedented application of techniques of physics to research into the structure of biological systems. But other disciplines too are facing changes in research techniques that may radically alter their nature. This may be exemplified by the broad introduction of aerial and satellite photography into ecology, which makes possible a rapid and quantitative assessment of basic parameters of the ecosystem as investigated over large tracts and recorded within definite time intervals.

Despite all the diversity of the research techniques employed, there exists a certain fundamental feature of the present-day equipment of the biologist -- its rapidly progressing computerization. The broad introduction of computers into biological research was anticipated by the Second Congress of Polish Science and, justly, even then regarded as a highly essential element of the immediate future. In world biology, computerization has by now become a fact, and in certain domains it is an indispensable premise for establishing and maintaining contacts with world science. This development is being accompanied, besides, by a marked decline in the prices of computers as well as in their operating cost, which should make it possible for our main research centers to acquire and utilize computers even during the current economic crisis.

There exist certain fields of biology in which work in the absence of computers is simply impossible. This concerns, e.g., numerical taxonomy, genetics and generally speaking population biology; environmental biology and in particular mathematical simulation of the state of environment and prediction of its changes; and molecular biology and in particular the modeling of complex macromolecular structures and of the kinetics of the complicated processes occurring in living systems.

Using computers requires not only disposing of the facilities themselves but also a proper retraining of personnel as well as overcoming the psychological barrier within the scientific community.

An Attempt at Formulating Scientific Priorities

There exist many proofs that science does not advance uniformly along the entire frontier of knowledge, but rather sometimes creates highly advanced outposts relating to progress made in particular domains. The biological

sciences also do not advance uniformly -- this is eminently demonstrated by their aforementioned polarity as reflected in the particularly rapid progress of molecular biology and environmental biology. The very logic of the worldwide advances of biology thus affords certain foundations for selecting research priorities. If we wish to participate in the advances being made in the most vigorous directions of modern science, we must take into account the world trends of these advances. But this is not the sole criterion for the selection of priorities. Allowance must also be made for an evaluation of our potential possibilities for joining in the main world trends of research, for our previous traditions and accomplishments (often outstanding but not necessarily accommodated within the mainstream of contemporaneity), and lastly for the country's actual needs and the prospects for the eventual applications of research in practice.

Selection of priorities always entails certain hazards, e.g., those ensuing from an inaccurate assessment of the situation of world science or from an erroneous forecast of the socioeconomic development of this country. Hence, all longrange planning in science must to some extent allow for a margin of safety, contain at least in embryonic form elements of an alternative solution.

In identifying the development trends of modern biology Department II of the PAN guided itself by two-stage studies performed by its its scientific committes (assessment of the implementation of resolutions of the Second Congress of Polish Science and determination of research priorities for the next 15-year period) as well as by opinions of eight experts who presented their own views to the Department. Important complementary material was provided by the assumptions of 46 basic-research projects and 11 utilitarian projects for the years 1986-1990, transmitted to the Department by PAN institutions. In the course of the work on their qualification and evaluation by the Department and by the Interministerial Commission for Evaluating the Implementation of Basic Research, it was possible to collate and compare them with analogous concepts evolved at the biology departments of higher educational institutions.

The Department thus had at its disposal extensive analytic and conceptual materials, which helped us to formulate a view of priorities over a longrange time frame (15 years) as well as of priorities with a shorter time frame (5 years). The latter also served to draft proposals for the research program for the next 5-year period (1986-1990).

The determination of research priorities for the biological sciences over the longrange 15-year time frame is immeasurably difficult, because an extrapolation of current development trends may be misleading. It is to be believed, though, that the following two problem groups will retain their exceptional importance and rapid rate of development:

1) molecular biology along with genetic engineering and biotechnology, and

2) environmental biology, i.e., ecology and the science of protection of nature and environment.

There exist two other problem groups that largely complement the above:

1) cell biology and physiology of animals and plants as a science of cellular and organismal integrative system mechanisms, and what we propose to define as a complex of:

2) comparative and systematic biology (in our country evolutionary biology, botany, zoology, parasitology, and anthropology should be included in this complex).

The order of enumeration of these problem groups corresponds roughly to the presumable hierarchy of priorities that will persist until the end of this century.

It is to be believed that molecular biology will be one of the most rapidly advancing fields of science in general. Techniques for manipulating the genetic apparatus and cellular techniques will be employed in biotechnology as mutually complementary procedures and will lead to a number of important accomplishments in medicine, agriculture, and industrial technology.

A separate highly important task is the popularization of the principles and achievements of molecular biology, genetic engineering, and biotechnology among the chemist community, at corresponding departments of higher educational institutions, and especially at polytechnics. This will assure a better preparation of future industrial personnel for the adoption and use of biological technologies.

Environmental biology will in the future be concerned with investigating global processes, the functioning of the entire biosphere or planet, and rely broadly on the use of satellite and biogeochemical techniques.

There will presumably occur a rapid development of theoretical biology, and attempts to formulate a theory of living systems will be undertaken. A new evolutionary paradigm that allows at the same time for the thermodynamic, structural and adaptational aspects of evolutionary processes may be formulated. Such a treatment will be broader than that represented by the currently fashionable concepts of modern neo-Darwinism.

We shall consider the research priorities with a shorter time frame (1986-1990) on guiding ourselves primarily by the studies conducted by the scientific committees of the PAN and the 1986-1990 program for basic research as ensuing from these studies and the associated proposals.

A practical expression of the identification of priorities with a shorter time frame (until 1990) and the utilization of the large number of recommendations made by the institutions of Department II of the PAN is the 1986-1990 program for basic research, confirmed by the Secretariat of Department II of the PAN on 28 January 1985.

Parallel to this work, broadly conceived interdisciplinary agreements have been concluded, along with negotiations with certain ministries. In particular, this concerns the program for molecular biology and biotechnology.

The PAN has received several analogous proposals (assumptions) from discrete science communities; among others, the bioorganic chemist and microbiologist communities have been highly active in this respect. Patronage over these communities is exercised by, in addition to Department II of the PAN, also Departments III, V, and IV, which authorized the Department of Biological Sciences to convene a broad conference (in December 1984) and thereupon to appoint a special commission under the direction of Prof M. Wiewiorowski, which has proposed assumptions of the central R&D program relating to biotechnology. Similar consensus has been reached within specialized science communities as regards revising the program for research into cellular biology, so as to combine it with research into neurophysiological problems, as well as regards programs in environmental biology and their place in the national research system.

At sessions of the Interministerial Commission for Evaluating Problems of Basic Research, attempts have been made to integrate the concepts presented by higher educational institutions and PAN institutes. During the discussions that are under way the aim is to eliminate part of duplicated research or excessively fragmentary projects so as to create the foundations for an integrated program, but this work has not yet been completed, so that the presented version of the program may yet be revised.

As a result, the PAN's Department of Biological Sciences presents, on behalf of the entire biologist community, the following program for biological research in the years 1986-1990:

1) Department II proposes revising the research program in the field of molecular biology so as to place stress on its applications in biotechnology and genetic engineering , along with the establishment of a corresponding application program comprising a series of properly selected problems. The program should integrate the resources of the PAN, as well as a substantial part of the related national resources. It proposes broad-scale coordination and outlays serving to link cognitive and utilitarian research, assuring -- given effective coordination -- marked advances in the field of research, and unlocking prospects for the application of modern biological technologies in various domains of life and the economy.

2) The Department proposes a radical transformation of the submitted outline of the program "Eukaryotic Cells in Norm and Pathology" into a program with a much broader scope, to be termed "Physiological and Biochemical Regulation Mechanisms of the Cell and the Organism, which by the same token includes physiological aspects. The absence of physiological topics in the program of Department II of the PAN has been a keenly felt gap as a result of which in Polish biology the integration levels existing between the cell and the ecosystem were not adequately investigated. The principal part of the revised program is to be based on merging research into cell biology (MR [Interministerial Program] II.1) with a thematic group comprising the neurophysiological research conducted at Nencki Institute under a research program currently coordinated by Department VI of the PAN. This new concept will serve to better exploit the resources of the PAN's Institute of Experimental Biology as regards neurophysiology and the directions of basic research. In addition, the program for R&D work on plant physiology, which is

being implemented chiefly as part of the program for agricultural and forestry sciences, should be supported.

3) It is proposed that many recommendations from the field of the botanical sciences be combined into an integral program, "Exploration and Utilization of Plant Resources , integrating the facilities and resources of the PAN's Institute of Botany, the PAN's Institute of Dendrology, the PAN's Botanical Garden, and a large number of other cooperating institutions. Such a program is distinguished by favorable proportions between its cognitive and applied parts (e.g., storage of seeds of arborescent plants, phyto-reclamation of urban environment). The concerned institutions of the PAN and the botanist community view this favorably.

4) The program for research in environmental biology will be implemented in cooperation with the MNSzWIT [Ministry of Science, Higher Education and Engineering], whose institutions (SGGW [Main School of Agriculture]) will coordinate a comprehensive program for research into environmental protection that would have the rank of a CPB-R [Central R&D Program]. As for the PAN's Institute of Ecology, it has been entrusted with coordinating the program (CPBP) [Central Program for Basic Research) comprising basic ecological research. In addition to advancing research into bioenergetics, population ecology and the functioning of ecosystems, a program for monitoring water and forest ecosystems and a program for optimizing the regional network for nature conservancy will be implemented. Action also will be taken to regenerate lakes and promote biological methods of agricultural pest control.

5) It is proposed that research into evolution be focused on problems of the mechanisms and course of evolution as well as on the generalizations of theory that ensue directly from the empirical research under way. This does not mean that explorations of theoretical biology will be abandoned; this simply makes greater allowance for the particular directions of the scientific schools and laboratories arisen in Poland.

6) A new program for research into anthropology is presented. This program is oriented toward the identification of differences among the main social strata in Poland as yardsticks for the wellbeing of the individual.

Proceeding from the premise that subjects of an utilitarian nature emerge in the biological sciences in close connection with cognitive research, derive their inspiration from that research, and are resolved in measure with progress in basic research, care was taken to assure that research projects (recommendations by the scientific secretary of the PAN) and government orders would complement the program for cognitive research, without being incorporated in that program.

The research program in the biological sciences is thus primarily based on interministerial basic research programs that are open to all scientific institutions in this country. The attitude of the science community toward the organization of research, and in particular toward to national research programs coordinated centrally under a uniform plan, has been inconsistent and changeable. This attitude has also undergone a marked evolution; not so long ago, the opinion was predominantly critical, while the proponents of targeted

funding and central coordination plans were less numerous. Now, however, opinion in favor of retaining national basic research programs predominates, and recent critics of these programs nowadays not infrequently stress that they are simply an indispensable prerequisite for the advancement of their disciplines and of science as a whole in Poland. Such a lability of opinion clearly does not facilitate laying down a consistent line of approach, but the experience gained as regards the biological sciences as well as a realistic view of the present situation are in favor of retaining basic research programs as the main form of organizing research work. These programs have been enriched with research projects and government orders.

The very concept of the basic research program has changed markedly. The maximalist approach, according to which a program should serve to solve a scientific problem or solve logically interrelated groups of such problems within the framework of one or another cognitive strategy, was combined with anxiety about the fate of research centers and scientific disciplines. From time to time PAN authorities ask to what degree does the existing system for the organization of research assure the development of scientific disciplines and schools, although sometimes they also claim that the programs merely serve to solve the problems posed by science and practice, rather than being a way of keeping the research centers in operation or practicing the scientific disciplines.

Such a variability of approach merely reflects the dialectics of the issue. An extreme view, represented by, e.g., K. Popper ("Postscript to the Logic of Scientific Discovery," 1983), postulates that science consists of problems, and of problems alone, whereas scientific disciplines, such as botany or physical chemistry, are merely "administrative units." But such a view is unacceptable and appears dangerous.

It must be admitted that topics of basic research in the program for biological sciences are only to a degree oriented toward problem-solving, being also markedly oriented to promote the advancement of scientific disciplines and continue the traditions of our main scientific schools. We are convinced that these dual functions of the research program are indispensable and mutually complementary.

Conditions for Implementing the Program for Biological Research

The conditions for implementing the program for biological research are as follows: 1) financial outlays; 2) investments in equipment; 3) investments in construction and availability of premises; 4) a network of laboratories; 5) other conditions considered essential in committee studies.

The financial outlays postulated for the program for biological research (for all its items), as proposed by the PAN institutions, are calculated at 24,216 billion zloty for the years 1986-1990, whereas the PAN Bureau for the Planning and Organization of Research proposes outlays of 21,467 billion .pa zloty. The difference, 2,749 billion zloty, will be subject to further negotiations.

These outlays must be complemented with corresponding amounts of foreign exchange for foreign-exchange areas I and II ["socialist" and "capitalist"] chiefly for the acquisition of equipment and spare parts, subscriptions to periodicals, and acquisition of books and other materials. The related needs for the 1986-1990 period may be estimated (for equipment and spare parts alone) at 2,250 million rubles and US$3 million, respectively, per year.

Department II of the PAN believes that the basic infrastructure of the biological sciences (arboretum, botanical garden and especially the expansion and maintenance of collections of living plants, collections of microorganisms, herbariums, museums, and certain libraries of special importance) should be funded on the basis of special orders by the scientific secretary of the PAN; the implementation of these orders should also be supervised by Department II of the PAN.

A consequence of the thesis of the great role of the biological sciences in modern science should be changes in the allocation of resources for research and investments, such as to increase real outlays on biology. The heretofore extremely conservative funding policy of the PAN with regard to the needs of biology can only testify to the underestimation or insufficient understanding of the postulates of the biologist community in Poland and failure to perceive the situation that has arisen in world science.

[The needs for] Investments in equipment for the laboratories of the PAN's Department of Biological Sciences have been assessed by a special commission working under the direction of Prof K. Wierzchowski. Two time-horizons of needs were distinguished: the immediate "breathing-room" time horizon and the longer-range time horizon of "indispensable needs." The commission's postulates are contained in an appendix. Most of the proposed equipment investments are of fundamental importance to implementing the program for the research and development of the concerned disciplines. This may be exemplified by the nuclear magnetic resonance (NMR) spectrometer, the need to acquire which had already been postulated by the Second Congress of Polish Science. The resources of several scientific institutions should be combined in order to acquire this fundamentally important equipment. Unless other such crucial equipment is acquired, the research envisaged in the program cannot be accomplished; this equipment is essentially a bottleneck to biology in Poland.

Construction investments and availability of premises. Among construction investments the following are of special importance: 1. construction of the building housing the PAN's Institute of Biochemistry and Physics in Warsaw, which should constitute an integral part of the central program for R&D in biotechnology. Department II of the PAN emphatically stresses that the housing conditions of the Institute are so poor as to be one of the principal obstacles to the development of molecular biology, genetic engineering and biotechnology (and also microbiology and virology -- see below). Hence also, the on-schedule commencement of construction and its conduct at a satisfactory pace are an absolutely indispensable prerequisite to progress in reseach and applications in the abovementioned fields; 2) commencement of construction of the Biological Center in Krakow where, in accordance with the project of the Krakow community, premises would be provided for many laboratories of Departments II and V of the PAN. The present premises of biological

laboratories in Krakow are very poor; they are in most cases housed in fortuitous and only partially adapted premises. The establishment of the Biological Center, for which a construction site has already been assigned, would radically change working conditions in these laboratories and make it possible to elevate the research standards by forming specialized laboratories. This will assure an improved utilization of the great intellectual potential of the Krakow community.

Many Warsaw research centers at present are housed under difficult conditions. They include: the PAN's Institute of Zoology, housed in a building which is under the threat of eviction owing to its poor condition, which harbors direct danger to the personnel; the PAN's Institute of Parasitology; and the PAN's Paleobiology Laboratory. Efforts to gradually improve working conditions at these institutions should be unremitting.

In the not too distant future (in the 1990's) the construction and adaptation of a complex of buildings designed for a modern natural history museum in Warsaw should be commenced and adapted: this is an institution whose absence on the cultural and scientific map of Poland entails many profound negative consequences.

Lastly, attention should be drawn to the difficult conditions, dispersal and absence of adequate standards at most of the premises of Warsaw University's Department of Biology, which complicate scientific work and up-to-date training of students.

Organization of Research and Network of Scientific Centers in the Near Future

As settled upon following prolonged discussion, the system for funding and organizing research, i.e., the identification of, in addition to central R&D projects, other research topics (which at the PAN are topics open to the entire community), and lastly also the identification of PAN research projects and government orders, makes considerable allowance for the postulates of the science community put forward in recent years. By constituting a form of reconciliation of the patronage and interests of the state with the initiatives of research centers, this system will, it is believed, pass its practical test in the next few years.

The organization of research and advancement of disciplines are greatly influenced by research centers. Within the PAN's system there is a keenly felt absence of a center for microbiology and general virology , whose establishment was postulated in the resolutions of the Second Congress of Polish Science. The attempts so far to organize that center point to the need to link its establishment -- at least in the initial stage -- to some parent center. In this case, Department II of the PAN favors linking the establishment of this new center to the Institute of Biochemistry and Biophysics and to the solution of the construction problems of that institute.

In the opinion of the PAN's Committee for Evolutionary and Theoretical Biology, there exists a need for establishing such a research center in Warsaw, best of all. The scientific program of that center and its affiliation have yet to be determined more precisely.

Department II of the PAN decidedly favors the commencement in the 1990's of work on establishing a modern museum of natural history in Warsaw, as based on cooperation between the PAN's Institute of Zoology and the PAN's Paleobiology Center, on utilizing the offer of the authorities to adapt a part of the built-up area within the confines of the Wilcza, Emilii Plater and Hoza streets.

The development of a modern research base will require implementing a number of tasks of an organizational-scientific nature . Here mention should chiefly be made of the establishment of: a central collection of microorganisms; a tissue culture center; a national center for the production of monoclonal antibodies on semi-industrial scale; a central herbarium in Krakow and expansion of its collections; and a central ecological library.

Research into modern and fossil floras and faunas requires comparative studies and suitable collections, which should be obtained by means of research expeditions. As the economic situation improves, the organization of such expeditions, which should best be interdisciplinary, should be resumed. Support should in addition be granted to mature proposals for such expeditions submitted by various institutions or individuals not operating within the PAN.

In view of the catastrophic restrictions on the acquisition of Western periodicals in all biological disciplines, a system of scientific information relating to discrete disciplines should be established on the basis of central libraries in a manner assuring contacts between Polish biologists and world science. Should not the operations of the PAN's OIC [Center for Science Information] be reformed? The reproduction system employed by the OIC is not meeting the needs of researchers as regards scientific writings.

There is a need for improving the situation as regards the publishing of Polish biological periodicals, shortening printing time, streamlining the graphics, providing better paper, etc. In particular, such conditions should be assured for several leading periodicals that are decisive to the Polish presence in world science .

Adequate means of transportation and greater allocations of gasoline for field studies are needed. This is indispensable to conducting research work in ecology, zoology, botany, parasitology, paleontology, and natural conservation. The current fuel restrictions are a major obstacle to the development of these disciplines.

Greater participation of Polish biologists in international symposia, congresses and conferences is postulated, as is the possibility of sending young people for longer-lasting assignments with the world's leading research centers.

Biology and a Formula for the Civilization of the 21st Century

Modern man links many of his expectations to the advances in the biological sciences. Feeding the growing population (and perhaps also biological control of demographic processes) and the fight against oncogenic diseases and

environmental threats are fundamental problems whose solution can be promoted by further advances in the biological sciences.

The use of conventional industrial technologies imposes limits on the further growth of the modern technological civilization. Hence, mankind can no longer follow this road. At the same time, modern societies are not willing to accept a drastic decline in their material welfare. Ideas of voluntary abandonment of the material comforts of life are as unpopular nowadays as ever, while the philosophy of asceticism meets with only a few supporters, some of them not being authentic supporters at that. The paths of anticulture are untrodden and may lead to a desert.

In such a situation, biology provides a unique opportunity for the further development of the basic material and intellectual features of our civilization. This is linked to, on the one hand, the utilization of biological systems and the mechanisms underlying biological processes as the foundation for a new technology. In the long run, this should assure highly productive industrial technologies, often waste-free or serving to utilize wastes and byproducts as well as substrates of lesser value. This would result in a marked curtailment of high-temperature, high-pressure, and energy-intensive conventional technologies, and thereby assure putting a halt to environmental degradation and improve the conservation of water, soil, and the atmosphere. The introduction of new biotechnologies will contribute to increasing crop and animal production by introducing new strains and breeding models, and it will assure a higher soil fertility and more effective pest control. Thus, the employment of unconventional biological methods in public health and environmental protection would contribute to improving the quality of life.

Furthermore, the application of ecological principles to economic organization, particularly as regards industrial siting and urbanization, a well as the introduction of systems for the monitoring, control, warning and forecasts of the state of the environment, would contribute to the rise and maintenance of a stable ecological equilibrium. Human environment would thus be marked by optimization of living conditions as regards health and psychosocial comfort. A new relation between man and nature, free of the heretofore dominant elements of a predatory approach, will arise.

Thus, it is a strategic task of the biological sciences at the present stage of their development to accomplish a radical change in the foundations of man's material existence and his attitude toward nature, by means of the biologicization of technology and ecologicization of industrial and agricultural production . There is reason to believe that the thus defined strategic task of the biological sciences accounts for a large part of the basic formula for the civilization of the 21st century.

The historical optimism engendered by the advances of modern biology should, of course, be viewed realistically. It cannot be forgotten for a moment that the road to the accomplishment of a new technological revolution, the last technological revolution of the 20th century, leads through a period of dramatic threats to natural environment, the motley legacy of the industrial technologies of the 19th century, and that it also demands of the world a

moral sophistication that would make it possible to avoid nuclear conflict and open the gate to the further advancement of mankind.

Medical Sciences

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[Report: "Current Status, Needs, and Directions of the Development of Medical Sciences in Poland" (Footnote) (Text of a paper by Department VI of Medical Sciences, PAN, prepared on the basis of materials of scientific committes under Department VI and of part of scientific committees under the PAN Presidium, which was a topic of discussion at the plenary session of Department VI held on 17 June 1985 with the participation of committee chairpersons, center directors, and chairpersons of specialized scientific societies); passages within slantlines published in boldface]

[Text] In recent decades the world's medical sciences have made considerable advances. These advances occurred in nearly every field of experimental and clinical medicine. Significant discoveries in genetics, molecular biology, immunology, and physiology have led to marked progress in the identification and treatment of many diseases and even to the total elimination of some. The growth of medical engineering, pharmacology, and the clinical sciences has contributed to much more effective therapy, the possibility of replacing certain organs and, in effect, prolonging the lives of patients, and also an effective physical and social rehabilitation of patients. Advances have also been made in the directions of medical research dealing with living, working, and dietary conditions and the dependence of societal health on the state of the natural environment. Progress in the medical sciences is so substantial that mankind is undertaking extremely ambitious programs with the object of assuring: 1) universal access to medical care and health protection for all; 2) fundamental improvements in natural environment and nutrition; 3) reduction in so-called social diseases. One related example is the fact that many countries have undertaken to implement the assumptions of the World Health Organization's program, "Health for All in the Year 2000."

The situation presented above was made possible owing to huge financial outlays on the development of the medical sciences, chiefly in the countries with a high level of economic and technological development. Genuine progress in the medical sciences has moreover required the coordinated effort of branches of science and industry. That effort placed at the disposal of modern medicine the resources assuring its progress.

The rapid development of science has resulted in an avalanche-like growth in scientific information. Each year the number of medical periodicals, monographs and textbooks is increasing. It is equally certain that the rate of obsolescence of scientific information has risen markedly. For the present-day researcher even a well-supplied library is not enough. He needs information systems that assist in recording and gathering published data, as well as systems for collecting scientific information. The collection, selection and processing of data are examples of cooperation between technology and medicine. The scope of this cooperation is growing, so that progress in the

medical sciences is no longer possible without a modern, efficient, and cooperative technical base.

The economic recession which the wold had experienced in the 1970's and 1980's contributed to the curtailment of science funding. In a large part of the world the achievements and advances of the medical sciences cannot be disseminated owing to economic considerations. Even so, each year there appear discoveries that are like milestones in the growth of medicine and that accelerate the implementation of ambitious plans of health services and unlock new vistas for the development of medicine. The development of sciences, including the medical sciences, is of great importance as a cultural determinant. Cultural factors are present in the very process of the identification and description of a phenomenon, in the dissemination of knowledge about human life and its conditions, in health education. The popularization of the achievements of knowledge is always linked to popularization of esteem for work and its results.

It was in these circumstances that discussion on the eve of the Third Congress of Polish Science was launched with the object of identifying our place in the development of science and preparing the decisions on the further development of the medical sciences in Poland as far ahead as the 21st century.

The present paper, which treats of the current status, needs, and directions of the development of medical sciences, was prepared on the basis of: reports from the scientific committees of Department VI; opinions of the scientific societies cooperating with Department VI; individual opinions submitted by PAN members; discussions at the plenary sessions of Department VI held on 1-2 April and 17 June 1985; and discussion at a session of the Secretariat of Department VI held on 25 April of this year.

All the materials of the scientific committees and plenary sessions of the Department are based on discussions of the theses and assumptions for the discussion on the eve of the Third Congress of Polish Science, published by the Congress Organizing Committee.

Medical Sciences in Poland

According to INFORMATOR NAUKI POLSKIEJ of 1983, medical 1,120 units of the university-chair, clinic, center, or independent laboratory type operate in this country. They employ 1,250 independent scientific associates and approximately 11,000 assistant scientific associates. The Ministry of Health and Social Welfare, the Ministry of National Defense, and the PAN employ a majority of the Polish medical personnel. Research organizations of the PAN chiefly engage in research into the theoretical sciences; they occupy a high position in this field and often coordinate national research programs. The largest group of scientific associates is suboordinated to the Ministry of Health and Social Welfare by being employed at medical academies and ministry institutes. Medical academies are of special importance, for they combine medical and research functions with the training of health service professionals. Yet, medical schools train excessively large numbers of students and at the same time operate inadequate instructional facilities and, in general, operate under poor social conditions which do not promote effective activity.

The funding of research into the medical sciences comes from several sources. The most important are the centrally controlled research programs (one government program, four "key" programs, three interministerial programs, and 15 ministry programs). Part of the funds derives from agreements concluded with industry. Enterprises of the extractive, power, metals, automotive, and pharmaceutical industries have allocated substantial funds for cooperation with the medical sciences. Moreover, many laboratories and clinics engage in so-called own research programs, with the funds for sponsoring their research, usually limited, deriving from their own budgets. Lastly, a major funding source for certain research centers is cooperation agreements with foreign research centers. These agreements are obtained through the implementation of governmental agreements for international cooperation or through private negotiations. These agreements usually provide the funds for service abroad by personnel, exchange visits of lecturers, and the acquisition of equipment.

Scientific life in Poland is organized by a network of scientific committees and commissions of the PAN, numerous specialized and regional scientific societies, and teams coordinating centrally controlled research. The role of the scientific societies in organizing scientific life and propagating scientific thought among the large numbers of professional health service personnel and researchers and academicians is particularly important. Owing to the scope and public nature of their activities, these societies are an important element in the propagation of progress. In recent years the economic consequences of the crisis have adversely affected the activities of the scientific societies, not infrequently resulting in their curtailment. This situation requires greater assistance for the societies, as well as measures to be initiated by the societies themselves to augment the possibilities for their work.

As assessed by the scientific committees of Department VI of the PAN, medical sciences in Poland have been developing as follows:

1) A major feature of medical sciences in Poland is the nonuniformity of development of both centers and fields of medical activity. In certain fields scientific development has been satisfactory, as evaluated by the criterion of the number of publications in high-standard international periodicals, good working contacts with eminent foreign centers, and the conduct of research in directions consonant with the progress of world science. The concerned centers usually also act as coordinators of large-scale research programs and organizers of international scientific conferences, and they are invited to participate in the solution of problems of health protection of a worldwide scope. It can be assumed that these centers have attained the average worldwide level of scientific development in the fields they specialize in.

There also exist centers at which development is not optimal owing to inadequate research facilities; they do not seek contacts with other scientific centers and their research does not often fall within the thematic scope of coordinated research. For such centers it is difficult to establish cooperation with foreign centers and develop up-to-date research techniques. Some of these centers, when originally established, were not provided with

proper conditions for unfolding their operations; instead they were provided with certain minimum resources for exercising instructional and medical functions, which do not assure the possibility of their scientific development.

2) Many critical comments have been made concerning the improper training of personnel in the medical sciences. Undergraduate training programs have been considered improper, the scope of the training of specialists has been criticized, and the system for conferring academic degrees and titles has been criticized as being too formalized and at the same time too liberal. It has been pointed out that the training of good scientific associates and the advancement of qualified persons to leading posts are of great social and economic importance. Still, despite the critical assessment of the training system, the scientists generally enjoy a good opinion. It is believed that Polish scientists are well-prepared for scientific work, that they are resourceful and their skills are proved in contacts with foreign cooperants. The reasons for this discrepancy between the training system and its consequences may be the self-education of Polish scientists and the growing extent of their assignments abroad.

3) Working conditions in the medical sciences are poor. This is chiefly due to the acute shortage of investment funds for the needs of scientific institutions. Most of these institutions are housed in old and worn buildings whose facilities are most often are under prolonged repair. The new buildings, where they are being erected at all, are being erected at such a slow pace that, once their construction is completed, they no longer meet the actual needs of the institutions. Obsolete scientific equipment that has not been renovated for many years is subject to sudden total breakdowns, often leaving research teams without the possibility of continuing their studies. The situation in this respect is particularly critical in the diagnostic disciplines, roentgenology, and nuclear medicine, whose technological backwardness is reckoned in decades. The situation has been greatly aggravated by the economic crisis, which impeded equipment imports and caused domestically built equipment to be unavailable.

4) Poor working conditions, inadequate facilities, and low pay, generally below the nationwide average, account for the low attractiveness of scientific work to youth. It also happens that capable and enterprising organizations abandon scientific work in favor of some other road of life. This concerns chiefly the theoretical specialties in medicine. Some of them may, owing to their low level of employment in relation to needs, or for other reasons, be termed deficit specialties. These include, among others, pathological anatomy, clinical analysis, medical microbiology, radiology, nuclear medicine, anaesthesiology, and intensive therapy.

At certain medical schools and institutes a growing organizational dispersal is observable. Two- or three-person laboratory or clinic teams are arising. This is a disturbing trend. There exists an optimal size for a research team capable of performing research tasks satisfactorily. Teams that are too big or too small do not assure proper utilization of the resources allocated for research purposes.

6) In recent years the number of Polish scientific publications in the medical sciences has been declining. This is demonstrated by the failure of nearly all periodicals to utilize articles for publication submitted in 1984 as well as by reports on empty editorial desks. To be sure, many articles are being published by Polish scientists in international publications, which promotes propagating Polish scientific accomplishments, but the decline of publications in Polish periodicals is due not only to the sending of articles to foreign periodicals. It may be that this is a transient effect of the crisis, whose consequences appear more tardily in scientific institutions and are longer-lasting than in economic life.

7) The abovementioned elements of the assessment of the situation of the medical sciences in Poland point to the lag of these sciences behind the world research advances, as has been literally stated in many opinions.

The above comments pertain to the entire range of medical sciences. Certain fields with their own specific features will be discussed below, with allowance for the general division into discipline groups. We wish to offer a number of comments concerning the biomedical and clinical sciences as well as a broadly conceived environmental medicine.

Biomedical Sciences

The scope of the biomedical sciences encompasses all theoretical medical specialties and pharmaceutical sciences. They are a major part of scientific activity in medicine because, on the one hand, they combine biological sciences with problems of human pathology and, on the other, they transmit difficult and still unresolved medical problems to the broad forum of the basic sciences. There seems to exist a definite pattern of development in the sense that genuine advances in medicine and health protection are linked to the utilization of discoveries made in the biomedical sciences. In the history of medicine there exist many facts pointing to the decay of medical sciences in the absence of a proper biomedical substructure. Through the mediation of the biomedical sciences medicine finds easy working contacts with other branches of science, and not infrequently joint scientific committees sponsored by several departments of the PAN are appointed, e.g., the Committee for Biochemistry and Biophysics, the Committee for Microbiology, and the Committee for Anthropology. Scientific committees concerned with physiological sciences, neurophysiology and pharmacology, immunology, cell pathology, human development, and medical physics are associated with Department VI.
From assessments by scientific committees it ensues that biomedical specialties are represented by considerable human resources, a large part of which is engaged in implementing centrally coordinated programs. The allocation of substantial resources on coordinated research, on the one hand, and the commitment of highly experienced research teams to these tasks, on the other, have made it possible to attain major and significant results in these fields despite the aforementioned difficulties. The fields concerned are:

-- experimental and clinical immunology;

-- neurophysiology and neuropathology;

-- pharmacology, especially neuropharmacology and pharmacology of the circulatory system;

-- physiology of the alimentary system, especially as regards internal secretory activities.

It also ensues from the opinions of the committees that the following major difficulties exist in implementing research programs:

-- the facilities of Polish laboratories are such that, despite substantial investments in many fields, research is not being pursued at a sufficiently rapid pace and its topics are undertaken by foreign laboratories with better facilities. In order to obtain the same results as the foreign centers, researchers in our laboratories must exert incommensurate effort;

-- lack of interest in research on the part of industry. This concerns chiefly pharmacology and the pharmaceutical sciences, whose well-conducted basic research is not supported or developed by industry;

-- several reports point out that the conditions of the crisis under which scientific institutions operate force them to alter their research plans or abandon certain planned directions of research;

-- the insufficient breeding and poor quality of laboratory animals prevent many experiments from being carried out in accordance with the assumptions under reproducible conditions.

Below we present opinions and recommendations on the development of certain biomedical disciplines that are of special significance to the development of the medical sciences.

Molecular biology. There is currently no domain of medical or biological sciences that is not interested in research at the molecular level. Basic advances in genetics, immunology, pharmacology, and pathology have been achieved thanks to research at the molecular level. In addition to medicine, many fields of research and production are interested in molecular research. Hence, interest in the development of molecular biology is broad. In Poland, however, the situation of this fundamental branch of research is not good, owing chiefly to the nonfulfillment of the development program resolved upon by the Second Congress of Polish Science. Despite good research programs and the sometimes interesting research findings obtained, in this field too symptoms of a lag behind the world progress are being observed. The development of research directions in the basic disciplines allows the development of applied directions and a proper assessment of scientific progress. The shortage of resources for the vigorously developing fields of the basic sciences results in limiting the development of the applied directions. By way of an example it is worth noting that the inadequate investments in and inadequate development of biochemistry years ago have resulted in limiting the development of biotechnological methods and the scope of their application to production. Circles interested in developing molecular research in medicine believe in the need to reorder the hierarchy of

importance of social and state needs in such a way as to promote better progress in the medical sciences.

Physiological sciences comprise in scope several disciplines concerned with the functions of the organism in norm and pathology as well as with changes in the mechanisms of response of organisms under varying conditions. Physiological problems are close to many fields of science other than medicine, and primarily to the agricultural and veterinary sciences concerned with animal physiology. Through pharmacology, the physiological sciences maintain broad contacts with the pharmaceutical sciences and the pharmaceutical industry.

The Third Congress of Polish Science should offer a new view of the role of the physiological sciences in view of the drastic changes in not only the human but also the animal environment. In the light of this, the importance of research into mechanisms of adaptation to the changing external environment is rising. This requires both expanding and intensifying research work at all physiological institutions and changes in the system of instruction as well as in the system of linkages between the physiological sciences and various domains of the national economy.

A special issue is the development of the pharmacological sciences and their relationship to drug production. It should be emphasized that original Polish drugs have been developed in research institutions rather than in industry, although in other countries priority in this fields belongs to industrial laboratories. For while the development of scientific institutions has been extensive, there is a shortage of industrial research laboratories in this country, which complicates the transmission of scientific thought from the scientific institution to industry. One postulate of the physiological sciences is the establishment of close working contacts between pharmacology laboratories and pharmaceutical industrial plants.

In Poland highly advanced research into neurophysiology is under way, especially into the neuroregulation of respiration and circulation, which is of direct benefit to the clinical sciences. The further effective development of these research directions requires expanding research facilities and the information system.

A broad range of cytological, cytochemical, cytopathological, neuropathological, and other research problems is comprised within the concept of cell physiopathology. Modern cytological research employs a great variety of research techniques, starting with molecular and biochemical ones, going through all the applications of electronmicroscopy, and ending with cytophotometry, interferometry, stereometry, and classical cytochemical techniques. Elements of cell pathology are present in a great deal of medical research, independently of the basic disciplines. Progress in cytological and cytopathological research is decisive to the growth of knowledge of pathological mechanisms. Similarly, a considerable part of clinical diagnostics is based on cyto- and histopathological techniques. For these reasons, this direction of research is also of major importance to the health service. From the social point of view what matters is not only the development of the research direction represented by cell pathology but also the training of large numbers of medical specialists. The attractiveness of work in these specialties is generally low, and the state of the facilities inadequate, which accounts for the low influx of young people to the concerned institutions. As a result of this situation, e.g., pathological anatomy has become a deficit specialty requiring special solutions in order to meet the needs of the health service.

Immunology at present occupies a special position among the medical sciences. It deals with the defense and regulatory functions of the immunological system and, as such, it is a domain of knowledge incorporated in all medical, clinical, and theoretical specialties. A reflection of the special role played by immunology in modern medical sciences has been the repeated (in 1980 and 1984) awarding of Nobel prizes for advances in immunological research. The numbers of immunologist personnel in Poland are large, but supply and equipment problems cause an incomplete utilization of their intellectual potential. Of special importance to immunology is the maintenance of broad international contacts. It is also believed that the development of medical engineering and biotechnology is of great importance to the future of immunology in Poland. Immunological research in Poland is largely comprised within a central research plan coordinated by the Institute of Immunology and Experimental Therapy, PAN. The implementation of this coordinated research has contributed to a marked elevation of the level of research and the propagation of scientific thought on immunology in this country.

Microbiology and virology are most closely linked to immunological research. Like immunology, microbiology is linked to every specialty of medical sciences. In view of the interdisciplinary nature of microbiology, the related research is contained in the research programs for biology, agriculture, veterinary science, horticulture, and other branches of science. The importance of microbiology to the medical sciences is obvious. In view of the growth of contagious diseases in this country, research into both diagnostic and therapeutical techniques is facing increased tasks. The principal emphasis should be placed on the genetics of microorganisms, including viruses. In view of the growing tasks, the facilities and personnel of the Polish scientific institutions in the field of microbiology and virology are inadequate.

The concerned specialists suggest a major expansion of microbiological training for the needs of clinical diagnostics as well as for research needs. Also being postulated is the establishment of an institute of virology under the PAN that would coordinate and develop research in this important biomedical discipline.

Medical physics and biophysics have a scope that includes several disciplines related to clinical diagnosis, radiation therapy, and radiation shielding. In view of the growing obligations of the health service and the deteriorating state of the natural environment, the importance of the tasks and the research needs relating to medical physics are increasing. Scientists point to the growing deterioration of facilities at scientific institutions, especially in view of the marked technical advances made elsewhere in the world, as well as to the total absence of investment projects in these scientific disciplines and the deficiencies of trained personnel. New directions of applied research are being postulated, along with better methods for training personnel and solving the problems of medicine and health protection.

Pharmaceutical sciences comprise multidirectional research into drugs of natural and synthetic origin. This research is fundamental to determining the structure of drugs, the relationship between their structure and effects, and their absorption and metabolism in cells and tissues. Applied research into successive stages of drug technology also has been developed. The pharmaceutical sciences are, in addition, concerned with important domains of diagnostics and analytics, chiefly biochemical, and they are included in the research into environmental protection.

Pharmaceutical sciences are chiefly linked to the pharmaceutical departments of the medical academies at which specialties at the boundary line between the clinical and the pharmaceutical sciences, such as biopharmacy and clinical pharmacy, are being developed. In addition, pharmaceutical sciences have numerous links with the chemical, biological, agricultural, and nutrition sciences. The organization of drug research in recent years must be considered relatively ineffective. The interdisciplinary nature of the development of new drugs requires a more effective coordination of activities as well as greater funding. The concerned groups of scientists suggest the appointment of a scientific committee within Department VI that would coordinate and assess progress in all the aspects of drug research.

Clinical Sciences

The scope of interest of the clinical sciences comprises the development of medicine in all specialties, diagnostic specialties, and prophylactic measures. Clinical sciences are served by many auxiliary specialties, such as transfusiology, tissue and organ preservation, dietetics, etc., which have become distinct branches of medical knowledge. A special position in the clinical sciences is occupied by physical, vocational, and social rehabilitation, which allows expanding medical activities beyond the immediate scope of the health service. Clinical sciences are represented in several scientific committees, namely: Experimental Therapy, Clinical

Pathophysiology, and Human Development, as well as in some of the other committees of Department VI.

Clinical sciences are so strongly linked to the problems of health service that, even in the opinions of committees dealing with scientific activities, the shortcomings of treatment are placed first. The first and most important conclusion derived from an analysis of these opinions is that: "Medical, instructional and scientific activities are so closely interrelated, and so interdependent, that their development has to be considered integrally." A lag in one of these forms of activity as regards medical sciences automatically entails shortcomings and lags in the others.

The assessment of the state of clinical sciences by the scientific committees points to a large number of shortcomings:

-- major deficiencies in auxiliary personnel, such as nurses, laboratory assistants, technicians, and medical assistants, which results in a marked lowering of the level of diagnostic and medical services;

-- substantial shortcomings in the influx of scientific information, a limited number of periodicals, virtually inefficient information systems, limited participation in international congresses;

-- limited possibilities for training abroad, so important to the advancement of personnel;

-- obsolete and most often inefficient diagnostic facilities;

-- extremely difficult, and in some places even primitive, working conditions at health service institutions.

This list of grave shortcomings, some of which have been existing for many years, has already led to extremely adverse consequences, namely, as mentioned in the opinions of the scientific committees:

-- the lag behind the development of world science in the domain of non-operative clinical sciences is explicit, and it has even been termed "professional decline";

-- limited influence of Polish scientific thought on the world development of clinical sciences;

-- owing to technical and diagnostic shortcomings and the overload on medical institutions, the number of patients with access to modern effective treatment has been declining; this trend was termed "the rise of elitist medicine."

Clinical sciences occupy a particularly exposed position in the medical sciences, because they employ the largest numbers of medical personnel and are a major part of the health service, which always is of lively interest to the public. The extent of the shortcomings and negligences complicating the pursuit of research in the clinical sciences is particularly disturbing.

The noteworthy achievements of the clinical sciences in recent years are as follows:

-- physical, vocational, and social rehabilitation;

-- immunology, especially skin diseases;

-- treatment of hyperplastic diseases of the circulatory system;

-- diagnostics of diseases of the nervous system, with special consideration of myoneural pathology;

-- operative treatment of metabolic diseases and certain vascular diseases;

-- introduction of prenatal diagnostics.

Such an important domain of action as that occupied by the clinical sciences is subject to numerous discussions on how to determine the proper model for the development of these sciences. It appears most expedient to allocate considerable resources for the solution of specific scientific and medical problems, and to assure central coordination of research within the framework of these problems. To use the world oncological research as an example, it can be stated that the marked prophylactic, diagnostic, and therapeutic advances achieved are due to an interdisciplinary approach to the solution of oncological problems with the aid of molecular biology, diagnostic specialties, clinical specialties, and the possibilities afforded by epidemiology and environmental medicine. An important factor also is the integrating function with respect to different scientist communities, the implementation of a common multidisciplinary task. Many other examples of this approach are, of course, known to us.

Conditions for the development of operative clinical sciences. The medical sciences developed at clinics represent the sum of biomedical and clinical knowledge leading to the exploration and effective combatting of pathological mechanisms. Operative clinical sciences presuppose effective surgical intervention, which in itself definitely contributes to identifying the pathological mechanism. The development of operative clinical sciences hinges on many factors. The first major group of factors is the development of technology, and especially of the production of modern equipment facilitating clinical and scientific activities. This group includes automated electronic diagnostic, measuring, and surgical equipment, automatic information systems, and manmade biologically neutral materials that can be implanted or grafted onto humans or used for other applications. An important condition is the degree of development of microbiology and virology. Progress in treatment continues, quite often, to depend on an effective protection of the patient against infections. Lastly, advances in endocrinology, physiology, and immunology assist in the prevention and treatment of traumas.

Anticipating further vigorous scientific advances, concerned science communities propose establishing closer cooperation with foreign centers, as based on an international division of labor, as well as setting up actual forms of cooperation between basic research and clinical institutions, linking

science to industry, and providing the motivating conditions for the development of the leading scientific groups in the clinical sciences as based on administrative and financial autonomy.

Development prospects of non-operative clinical sciences. The scope of interest of the non-operative clinical sciences includes not only the medical disciplines based on the principles of pharmacological treatment or physiotherapy but also many important problems ensuing from the menaces offered by social pathology, poor environmental conditions, food and nutrition, and other environmental aspects. This gives birth to the extremely important postulate of reorienting the main directions of reseach, which should be intended to maintain the health of the nation rather than merely to treat the existing diseases. In the treatment of diseases, despite the tremendous strides made in the last 40 years, we cannot catch up with the growing needs, and this is the main argument in favor of taking effective action to create more salubrious and safer living conditions.

The conditions affecting the development of non-operative clinical sciences require fundamental improvements in diagnostic facilities, in consonance with the development of modern medical engineering. These improvements include imaging techniques not based on ionizing radiation (magnetic resonance, ultrasonography), techniques based on new achievements of technology (single-photon tomography, positron tomography, and dynamic imaging methods). Another group of conditioning factors is the biotechnological techniques for the manufacture of drugs and reagents that facilitate diagnostics. The third group is related to the possibilities for streamlining the work of the concerned science personnel itself. Care should chiefly be taken to assure proper training, promote suitable candidates to leading positions, and exercise more critical judgment in conferring academic titles and degrees.

In neurology and pathology, close cooperation between theoretical and clinical disciplines has resulted in marked advances in the diagnostics, therapy, and rehabilitation of diseases of the nervous system. Neurological sciences postulate the development of computerized diagnostic systems and modern neuroimaging techniques. In view of the growing number of cases of diseases of the nervous system, the importance of neurological research and of the development of neurological care, which is of major economic significance, is rising.

In recent times the importance of psychiatry in our country, both as a medical specialty and as a research direction, has been increasing. The number of illnesses requiring the attention of psychiatrists is growing in connection with the rising numbers of cases of drug addiction and poisoning, social maladjustment, numerous cases of mental retardation, and other groups of psychopathology. Both in the pre-production and in the post-production groups [children and the elderly], problems requiring psychiatric care arise quite often. Both the research plans intended to determine the frequency, course, and conditions of social psychiatric diseases, and the measures to strengthen psychiatric service are important from the social standpoint. The development of psychiatric care entails the need to include other domains of sciences (psychology, sociology, pedagogics) in order to create the foundations for rational psychosocial activity.

Developmental medicine. Special attention is required by health protection for children and youth. Epidemiological studies point to numerous illnesses within that age group. In addition to the numerous diseases of the alimentary tract and the respiratory and urinary systems, a growing frequency of psychosomatic ailments, poisonings and traumas is observable. Particularly disturbing is the rise in drug addiction and alcoholism among youth. Treatment programs, especially rehabilitation programs, require the participation of many other sectors of the national economy in addition to the health service. It is an important task of the medical community to undertake extensive and continuous epidemiological studies of the health of children and youth. These studies should provide the basis for managing the resources and facilities of the health service. The research effort should be directed toward, on the one hand, expanding the treatment, especially prevention, of the disease groups for which treatment has already proved effective, and on the other, on expanding research into the exploration of pathogenetic mechanisms and the possibilities for treatment and rehabilitation of cases with diseases which, given the present state of medical capabilities, we regard as incurable.

Also important is combining the problems of preventive health care with pedagogical programs at every instructional level.

Physical, vocational, and social rehabilitation. Physical and vocational rehabilitation is of extreme social importance, since it restores the individual to his community and enables him to take an active part in life. In view of the growing number of the disabled and incapacitated persons in modern society, rehabilitation work is of extreme social importance not only for humanitarian reasons. Rehabilitation procedures restore to society valuable skilled workers and professionals, which is of definite economic importance. The scientific forms of physical, vocational, and social rehabilitation may be termed a Polish scientific specialty. The development of rehabilitation in Poland has become possible thanks to basing medical care on the social model of the health service and attracting the interest of many industrial plants and welfare agencies. The scientific development of rehabilitation is possible owing to the advances in the knowledge of biomechanics, physiology of the circulatory system, the motor system, and especially the nervous system. In addition to the rehabilitation of persons in the ablebodied age group, the social rehabilitation of youth following psychosomatic or psychiatric treatment as well as the rehabilitation of persons in the post-production age group, who often lack family support, are of special importance. Rehabilitation work is a logical continuation of medical care and should be developed on par with medicine and prevention.

Social and environmental medicine and health protection. In this Section we wish to present assessments of a broad range of scientific activities represented by the Committee for Human Ecology, the Committee for Human Nutrition, the Committee for Physical Culture, and partially the Committee for Human Development, as well as by many scientific societies. This group of sciences is concerned with the protection of man's health and his natural environment. Many environmental studies indicate that there exists a considerable threat to the natural conditions under which we live. In some

regions of this country, particularly the industrialized ones, the contamination of water, air and soil is many times above the maximum permissible limits adopted by the nation's sanitary service. It also is known that many indicators of the society's state of health have reached a disturbing level. The state of knowledge about sanitation also is extremely low, and the society appears to be very little interested in problems of health protection on the national scale.

From the opinions presented and discussed at the sessions of the scientific committees it ensues that:

-- measures to promote health protection require very active participation by the entire society and the entire state administration;

-- there exists a need for regular collection of data on the health of the society;

-- elements of knowledge about health and its protection should be introduced at all levels of education;

-- the sanitary service and its scientific and technical base should be markedly strengthened; that service should be given much greater powers than it has at present;

-- the national situation requires introducing a program for food protection. The production, transport, and storage of food at present are of an old-fashioned nature, which affects the quality and quantity of the food provided to the society;

-- physical-education science personnel has created the foundations for the science of physical culture and physical education. The principles already developed as part of health education should be applied to social life;

-- many of the assessments mention the issue of protecting the health of children, the family, and youth. Attention is drawn to the high mortality rate of infant-age children, and to susceptibility to contagious, psychosomatic and mental diseases. In the opinion of the Committee for Human Development, this matter requires considerable outlays and an expansion of research programs;

-- the high general mortality rate, and especially the high morality of ablebodied males, requires special concern and paying attention to the main causes of deaths, which include diseases of the circulatory system, cancer, accidents, traumas, and poisonings.

In these circumstances, medical research oriented toward protecting the health of the society and the natural environment is of fundamental importance. As known, 30 percent of this country's population live in ecologically threatened areas, and the number of noncontagious diseases lethal to a high proportion of the ablebodied population is rising. Ecological threats are created by industry, transportation, power generation and, partially, agriculture, in which, owing to the use of insufficiently controlled technologies, a major

health menace is arising. Obviously, in such a situation concern for health protection should not be left to the health service and the medical sciences alone. Measures to improve the nation's health situation must be above all extended to the branches of the economy in which this menace originates. As for the many scientific laboratories concerned with investigating environmental pollution, these must focus their attention on the causes, sources and dynamics of the propagation of harmful factors. Scientific institutions, too, should provide recommendations and instructions for coping with the unfavorably changing living conditions. The pollution of water, air, and soil is only one aspect of environmental medicine. An important health factor is interpersonal relations at the workplace, at recreation and at home. Judging from the growing number of persons seeking psychiatric assistance, this aspect of health also demands greater attention.

A major factor affecting the health of the society is the quality of nutrition. The aim of medical sciences in this respect was defined in 1981 as that of investigating the relationship between nutrition and man's life and health at the molecular, submolecular, tissue, individual, and populational levels. This definition implies an urgent need to initiate comprehensive research into the health aspects of the food produced in Poland and the consequences of nutrition to health. Parallel to that research, training at various levels should be provided for food producers. Thus this is yet another health-related problem that requires interdisciplinary solutions.

Many studies draw attention to the low state of health education and the lack, in our instructional curriculums, of elements of health education. At the same time, though, the sciences of physical culture are the best-prepared field for propagating knowledge about health education. Polish specialists in this field have considerable experience and noteworthy accomplishments. That experience and these accomplishments should be better utilized to improve the health of the society. The importance of the physical-culture sciences consists not only in their educational aspect. The training of a large number of rehabilitation specialists, the development of physical exercise programs for healthy and ill people of various ages, the care given to nurturing athletes, and the propagation of the most valuable aspects of physical culture represent a major contribution to national culture.

Development Directions of Medical Sciences

From the comments and appraisals presented above concerning the effects of medical sciences it ensues that the tasks they face are growing. To be sure, improvements in the state of health of the society do not depend on the medical sciences and the health service alone but require the combined effort of many fields of science and the entire society, but the duty of initiating and coordinating that effort will rest on the medical sciences.

The significance of the medical sciences to the development of the society was stressed during the discussions preceding the two previous congresses of Polish science. In these discussions, then as now, emphasis was placed on the need to increase the funding of medical sciences, motivating this by deeply understood social interest. In the studies prepared prior to the Second Congress, just as at present, the opinion was expressed that the declarations of the previous congress had not been implemented to a degree sufficient to create the foundations of modern medical sciences and an effective health service.

At present, however, the situation in which materials for the Third Congress of Polish Science are being prepared is different:

-- the list of our accomplishments is more modest than it had been before the Second Congress;

-- the state of health of the society has worsened markedly, with some indicators declining to the level of the 1950's;

-- the condition of natural environment in this country is disturbing;

-- the possibility of repairing past omissions at present is smaller than it had been years ago.

In such a situation the voice of the medical sciences at the Congress should sound differently than in the past. We can point to the consequences of omissions in our field of action, which are evident not only in the deteriorating state of health of the society but also in the economic consequences.

In view of the country's difficult economic situation it cannot be assumed that the funding level will increase to an extent meeting all the needs within the next few years. Yet, elevating the state of health of the society is a crucial task of the state; the role of the medical sciences in this task is obvious, and the funds needed for this purpose are indispensable.

In the theses for discussion drafted on the eve of the Third Congress of Polish Science the indication of the directions of research in discrete fields that could assist the national economy was considered. Medical sciences serve the national economy. Every action taken to prolong life or shorten the period of work disability has not only a humanitarian significance but also a definite economic significance, for it augments the resources of manpower, so important to the national economy.

We also are proposing more direct cooperation with industry, which in certain fields has already been developing for many years, as regards the application of innovations ensuing from medical research to production and hence also the modernization of production in several fields of the economy.

But a most important issue is procuring the funds and providing the personnel and facilities for the continuation of research in the major specialties

essential to medicine in which we scored tangible accomplishments in this country. This includes the following directions of biomedical research:

-- immunology;

-- neurobiology;

-- molecular biology and pathology, and especially human genetics and elements of biotechnology;

-- endocrinology and physiology with pharmacology.

Special care and conditions are required by the directions of research and measures of basic importance to the health of the society. These include, seen from the social point of view:

-- combatting diseases of the circulatory system;

-- the fight against cancer;

-- care of the child, the mother, the family, and youth;

-- the fight against mental diseases and research into their biological, psychological, and social background;

-- prevention of traumas and poisonings;

-- a broadly conceived environmental medicine that takes into account the problems of human nutrition, as well as labor medicine.

The Ministry of Health and Social Welfare has formulated the following basic goals to be accomplished by the public health service within the next 5 years:

-- prolonging the average lifespan;

-- reducing the excessive mortality rate of males;

-- reducing the mortality rate of infants.

These are the basic goals for the entire health service. The onus of these tasks clearly rests on the clinical sciences. Their implementation should involve extraordinary resources and extraordinary commitment.

The place of the medical sciences in the economic system of this country has so far not been even approximately determined. Economic discussions and decisions make no allowance for the economic significance of the development of these sciences and its resultant effects on the protection of health of the society. The outlays made on developing medical sciences are considered to be an incommensurate contribution to the general development of the society. Endeavors should be made to determine -- and this is feasible -- the real economic contribution of the medical sciences and of the measures promoting health protection to the national economy. This requires a separate investigation, which should result in new applied model solutions.

Technical Sciences

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[Article by Prof Dr Ryszard Pohorecki et al.: "Social Importance of the Technical Sciences" (Footnote) (This review paper by the Department IV, Technical Sciences, PAN, was drafted by Deputy Secretary of Department IV Prof Dr. Ryszard Pohorecki in cooperation with the members of the Department's Secretariat proper, namely: Department Secretary Prof Dr Bohdan Ciszewski; Deputy Department Secretary Prof Dr Tadeusz Sliwinski, and Councilor Scientific Secretary of the PAN Prof Dr Ignacy Malecki. This paper is based on reports from the scientific committees of Department IV of the PAN. After copies of this paper were sent to all members of the Department and discussed at the plenary session of 22 March 1985 of the Department, as well as at the open plenary session of 27 June 1985 of the Department, was revised and expanded to allow for the comments made at these meetings or sent in writing by the following persons: Prof Dr Zbigniew Bojarski, Prof Dr Witold Ceckiewicz, Prof Dr Tadeusz Cholewicki, Prof Dr Roman Ciesielki, Prof Dr Jerzy Dudziewicz, Prof Dr Jerzy Filipowicz, Prof Dr Wladyslaw Findeisen, Pro Dr Wladyslaw Fiszdon, Prof Dr Henryk Frackiewicz, Prof Dr Bronislaw Gajda, Prof Dr Zbigniew Gorny, Prof Dr Zbigniew Grabowski, Prof Dr Jerzy Grzymek, Prof Dr Witold Gutkowski, Prof Dr Janusz L. Jakubowski, Prof Dr Jan Kaczmarek, Prof Dr Maciej Kozlowski, Prof Dr Jerzy Krzyzanowski, Prof Dr Roman Kulikowski, Prof Dr Jan Madejski, Prof Dr Zdzislaw Marciniak, Gen Prof Dr Jerzy Modrzewski, Prof Dr Maciej Nalecz, Prof Dr Roman Pampuch, Prof Dr Bohdan Paszkowski, Prof Dr Jan Podoski, Prof Dr Witold Rosinski, Prof Dr Leon Rowinski, Prof Dr Wieslaw Seruga, Prof Dr Kazimierz Sekowski, Prof Dr Adam Smolinski, Prof Dr Bogumil Staniszewski, Prof Dr Wojciech Szczepinski, Prof Dr Robert Szewalski, Prof Dr Witold Szymanowski, Docent Dr Zbigniew Smieszek, Prof Dr Alfred Swit, Min Docent Dr Konrad Tott, Prof Dr Kazimierz Wejchert, Prof Dr Stefan Wegrzyn, Gen Prof Dr Edward Wlodarczyk, Docent Dr Jacek Wojtowicz, Prof Dr Tadeusz Zagajewski, Prof Dr Piotr Zaremba, Prof Dr Stefan Ziemna, Prof Dr Michal Zyczkowski)]

[Text] Technical sciences are a major factor in economic development and directly influence the living standards of the society. Linked to their advances are universal hopes for surmounting four principal barriers on the road toward the further development of mankind: the energy, food, raw-material, and ecological barriers. This concerns, among other things, the development of new methods for the generation and storage of energy, the development of industrial techniques for the production of food and feeds (biotechnologies), the development of advanced technologies for the production of new materials needed to overcome the material barriers to technological advances, the utilization of poor mineral deposits and seawater as sources of economically valuable constituents, and the development of waste-free and environmentally safe methods of industrial production, the participation of the technical sciences in solving these problems is indispensable.

The technical sciences also are a major cultural agent. This concerns not only technical culture in the traditional meaning of the word. The rapid development of new techniques for the recording, collection, processing and transmission of information is causing changes no smaller than those once caused by the invention of the printing press. A new informatic-electronic civilization is being created. The spread of information media is causing fundamental changes in techniques of design and production and the appearance of products of a new type -- intelligent devices with built-in microprocessors capable of replacing man in many activities that till now used to be his domain -- and, above all, it is revolutionizing instruction, culture, the circulation of information and the daily life of people. In modern societies the assurance of possibilities for the extremely rapid recording, collection and utilization of vast information resources has become a condition for the functioning of the organism of the state. In the technical sciences themselves, too, major changes occurred in recent years. They consist in, among other things, the rise of new and often unexpected applications of many fields of science, which has resulted in changes in the research profile of many world research centers, as well as in changes in the instructional profile of educational institutions. New research techniques have been introduced both in theoretical work (e.g., the universal reliance on computer techniques) and in experimental work (e.g., the far-reaching automation of experiments and data processing).

The tasks which the present poses to the world's technical sciences also face Polish science. The difficulties it is experiencing do not release it from the threat of forfeiting contact with world science, from the threat of cessation of further development once the crisis is behind us -- from participation in these tasks.

For this very reason the following two tasks, which are difficult to reconcile, arise as regards the technical sciences:

-- participation at those frontiers of the technical sciences in which we have something to say to the world;

-- implementation of the tasks posed by our economy.

At present in Poland the technical sciences too are making a substantial contribution to overcoming the crisis situation. They are important to raising the productivity and improving the organization of labor, to reducing the consumption of energy and raw and other materials, and to counteracting the depreciation of existing fixed capital. The attainment of these goals requires the development of technology, and one of the conditions for that development is the development of the technical sciences.

Here it is important to distinguish clearly between scientific activity and technical, engineering activity. The purpose of scientific activity with respect to the technical sciences is to broaden knowledge and refine the methods that can be used by the engineer in his professional work. Thus, these sciences are directed toward practical goals, but they are of not only applied but also cognitive nature. The purpose of technical activity is, on the other hand, the creation of specific engineering facilities serving to meet

particular social needs. In implementing technical tasks the engineer avails himself of the actual accomplishments of world science (chiefly of the technical sciences) and conducts the necessary tests and studies of the facilities created, which is not tantamount to scientific activity. Creative technical activity, e.g., creative design, is often termed the art of engineering. It plays a tremendous role and deserves a high social rank. It should be stressed that science is only one of the conditions for creative technical activity, although it is an indispensable condition. It is to be acknowledged that the tasks facing science differ fundamentally from those facing technical creativity, although a close interrelationship of both these forms of creative activity is an indispensable prerequisite for the complete utilization of the accomplishments of science and technology in the national economy.

The situation of the technical sciences in Poland is at present extremely difficult and in many respects even dramatic. The conditions for the conduct of research have gravely deteriorated in the last few years. Here mention should be made of, among other things:

-- steady decline in outlays on science;

-- depreciation of scientific equipment and laboratory facilities;

-- instability of organizational and funding forms;

-- inability of industrial enterprises to absorb [research results] and the decline in the number of applications;

-- insufficient influx of foreign scientific literature;

-- curtailment of foreign contacts.

A majority of the related postulates of the Second Congress of Polish Science has not been implemented; they still remain topical.

Despite the unfavorable economic situation, improvements in the situation of the technical sciences are needed. Any further postponement of these improvements threatens an irreversible loss of innovative ability in technology and a degradation of this country's technological level.

General Conditions for the Further Development of the Technical Sciences

Science personnel. The development of the technical sciences is linked to both the state of science personnel and the state of the engineering personnel employed in the national economy. The relationship between the development of a science and the numbers and level of the personnel creating it is obvious. Often, however, it is forgotten that the ability of the economy to absorb innovation and its stimulating effect on the scientific community hinge on the numbers, professional level, and creative ability of the engineering personnel employed in the economy. In Poland at present a rapid deterioration of the situation as regards both scientific and engineering personnel is observable.

As regards engineering personnel, this deterioration is associated with the explicit decline in the prestige of the engineering profession, due chiefly to the decrease in the financial attractiveness of that profession and the use of engineers for uncreative work that does not require higher education, as well as to the lowering of the level of training of engineers, especially at the smaller academic centers with their small staffs. The decline in interest in the engineering profession, clearly reflected in the decline in the number of candidates for engineering degrees, constitutes a serious threat to the economy, which within a few years may face a shortage of properly trained engineering personnel and all the consequences of that shortage.

The decline in interest in the engineering fields is also causing a decline in the numbers of qualified candidates for scientific work in the technical sciences. What is worse, even the few remaining candidates are unable to undertake that work owing to a virtual hiring freeze at higher academic institutions and at the PAN. That freeze is due to four causes:

-- the replacement of the traditional personnel policy, exercised by organization heads, with the formalized mechanism of the so-called "rotation";

-- decline of interest in earning higher academic degrees and ranks by the middle-level scientific personnel, owing to, among other things, the minimal differentiation of the salaries of adjunct professors, docents, and full professors, and the absence of hiring of qualified personnel by industry;

-- the granting of degree-conferring rights to many non-academic centers, which has impeded the transfers of middle-level personnel from academic institutions to research centers;

-- elimination of doctoral studies at higher academic institutions [as published].

The introduction of rotation has, true enough, increased the number of doctorates, but it also clearly lowered their level. What is worse, it firmed the conviction that the main aim of scientific work is the doctoral degree rather than the results of research.

A similar effect has been produced by the artificial integration of research sectors consisting in, among other things, imposing on ministry research centers a hierarchy of academic titles and a model of scientific development proper to higher educational institutions. Additional factors complicating personnel development are:

-- deteriorating conditions of research work (state of facilities, difficulties with access to literature, difficulties in international contacts);

-- poor material situation of science personnel;

-- poor housing situation.

A separate problem is the decline in the numbers of auxiliary personnel (engineer-technician personnel, blue-collar workers, service personnel). This decline is due to wage relations that are unfavorable for scientific centers. This necessitates using highly qualified personnel to perform simple auxiliary tasks, which reduces the productivity of their research work and compounds the frustration felt by the scientist community.

Surmounting these negative trends and their consequences is a fundamental problem to the development of Polish science. It is indispensable to provide conditions promoting transfers of personnel among research centers and from science centers to industry, as well as to strengthen working relations among research centers. The latter can be achieved by, among other things, expanding the system for the provision of scientific advice to economic organizations by personnel of higher educational institutions and the PAN, and by inviting high-grade experts from research centers and industry to lecture on engineering topics at higher educational institutions. The higher educational institutions themselves should become the source of personnel at all levels for other research centers and for the national economy -- and not as a result of a mechanical rotation but as a result of the transfer of academic personnel of their own free will to non-academic jobs. A major element of correct policy in this respect is a consistent system for evaluating the performance of individual scientists and teams. The possibility of hiring the ablest graduates each year for faculty positions at higher educational institutions should be restored; given the country's difficult situation, the wastage of talented scientific manpower is an inexcusable error. Efforts should also be made to restrict the number or augment the faculty of the weaker academic centers.

The system for the control, planning, and funding of science. Science policy is integrally linked to the nation's longrange economic, social, and cultural policies. The linkage between science policy and economic policy is particularly strong as regards the technical sciences. Science policy must in this connection be a longrange policy, because the time required to form research teams and scientific institutions is longer than in other domains of social activity, and the practical effects of research materialize only after several years. Hence, a basic prerequisite for the proper planning and control of the development of the technical sciences is the existence of a longrange concept of the social and economic development of this country, such as would be related to programs for scientific research. The resolutions of the Second Congress of Polish Science pointed to the absence of such a concept. Many central institutions and economic organizations lacked clear development concepts, focused their attention on the fulfillment of current production plans, expected of science and the research base sporadic assistance in activating production, and failed to formulate needs for preemptive longrange

research. Following the Second Congress this situation did not change, initially owing to the orientation of industry toward foreign solutions and the disregard of the role of domestic science, and subsequently owing to the crisis. It is to be borne in mind that one of the causes of the economic crisis was precisely the disregard of Polish technical and scientific thought and of the -- unfortunately infrequent -- criticisms voiced by technologists and scientists concerning the economic policy, and particularly the license-acquisition policy. The initial stage of application of the principles of the economic reform also is not promoting the formation of longrange concepts, for the enterprises are oriented toward the solution of current problems.

Another difficulty in formulating and pursuing a correct science policy is caused in Poland by the existence of three poorly interrelated research sectors: higher educational institutions, PAN institutions, and ministry institutes. The absence of coordination and explicit division of labor among these sectors, along with the attempts at their artificial integration, has resulted in the rise of organizational barriers impeding the flow of personnel and research themes, while at the same time prompting the phenomenon of mass applications for academic degrees and titles at certain research centers whose tasks hardly justify such degrees or titles.

A proper guidance of research into the technical sciences thus requires:

-- drafting a concept of longrange socioeconomic development of this country as well as of discrete branches of the economy (subsectors of industry, transport, the agricultural and food complex, the sphere of services).
The drafting of such a program making a comprehensive allowance for problems of the life and development of the nation requires using an interdisciplinary team of experts as well as techniques of systems analysis;

-- determination of the division of tasks among discrete sectors of science in this country.

The first of the abovementioned conditions will be discussed in more detail in the section on development strategy and research priorities. As regards the second, it is necessary tto create a coherent legal and financial system defining the role and tasks of each sector. Higher educational institutions and PAN institutions should primarily (though not exclusively) engage in basic research, while ministry research institutes should primarily (though not exclusively) engage in applied research. It should be clearly stated in this connection that the responsibility for training science personnel belongs to higher educational institutions.

In the light of the foregoing, it is clear that the system for the central planning, coordination and organization-oriented funding of research has to be retained, while at the same time stimulating direct cooperation between research centers and industry. This system, which at present functions in the form of targeted government programs, "key" programs, and interministerial programs, has met with a positive response, because it made possible the focusing of effort on important longrange problems, enhanced the integration of the science community and its feeling of stability, and lastly positively

influenced the development of scientific criticism. The maintenance of the system of centrally guided and funded R&D programs is particularly essential in the presence of the economic reform. Such programs should constitute a main instrument of science policy, by preventing excessive concentration on minor problems that are of immediate usefulness to discrete enterprises. It is also essential to maintain the decisive role of the coordinating teams, which consist mostly of representatives of science, as well as to augment the role of the PAN's scientific committees in the planning and monitoring of the fulfillment of tasks.

An increase in overall outlays on scientific research is indispensable. These outlays fell in 1984 to about 1 percent of national income, which causes our country to rank last among the socialist countries. The increase in outlays in 1985 has not as yet become tangible. What is more, a substantial part of these funds has not at all reached scientific teams and, instead, is returning to the state exchequer in the form of all kinds of surcharges and deductions. Here the characteristic examples may include the transfer to the state budget of deductions linked to the depreciation of buildings (which are depreciating owing to lack of repair), the taxes on the honorariums paid, or the deductions to the FAZ [Plant Activation Fund]. The last-named, in particular, are a glaring example of the misunderstandings to which the uncritical treatment of research centers on par with production enterprises leads.

The further development of science is impossible given the current low level of the outlays. These outlays must be at least comparable to the outlays which other countries with a socioeconomic structure similar to that of Poland consider reasonable.

The science community places great hopes in the recently introduced reorganization of the system for guidance of science and the establishment of the Committee for Science and Technology Progress and the Office for Science and Technology Progress and Applications. It has also responded positively to the announcement that outlays of science, as expressed in terms of percent of national income, will be gradually increased.

Integration and cooperation of science communities in this country. An important stimulus to innovative research ideas is cooperation among scientific centers. In Poland the possibilities for such cooperation remain practically unutilized. There is a lack of exchange of people and experience among departments and institutes specializing in the same discipline; yet, it should be stressed that this cooperation is indispensable to a correct division of tasks among the research sectors (disciplinary research chiefly at higher educational institutions, targeted basic research at higher educational institutions and at the PAN, targeted applied research chiefly at ministry institutes).

A positive role in promoting cooperation among research centers has been played by centrally funded and coordinated targeted research programs. As organized by coordinators, conferences and seminars (e.g., related to responses to research projects) influence positively the development of both scientific cooperation and scientific criticism. These forms of project assessment should be promoted. A great role may be played here by the

scientific committees of the PAN. Endeavor should also be made to publicize the processes of evaluating the whole of the scientific accomplishments of institutions and individuals -- this is a crucial means of stimulating scientific discussion and criticism, whose absence is commonly felt. Despite the many difficulties and perils that may occur in this respect, it is indubitable that assessments by the scientist community can be more accurate, less subjective, and less susceptible to pressures of a nonscientific nature, than individual opinions.

A basic obstacle to the exchange of scientists among institutions is the housing situation. An improvement in this respect could be produced by isolating a special pool of rotated dwellings, but that would be a provisional solution. A permanent removal of this obstacle is difficult to expect in the short run.

A highly essential element of cooperation among the various research sectors, and also between science and industry, should also be the previously discussed flow of personnel from higher educational institutions to research centers and industry, the system of scientific advisories for economic organizations, and the formation of interministerial teams with the participation of members of higher educational institutions and the PAN.

Research facilities and techniques. Adequate facilities are a prerequisite for the promotion of all experimental sciences. As regards the technical sciences, there exist additional specific requirements: in order to propose modern solutions suitable for practical applications, science must operate with research equipment that is no worse than that of industry. In the 1970's the state of the facilities of science in Poland relatively worsened; the expansion of these facilities lagged behind that of industry, which was bound to reduce the innovative potential of research centers. During the crisis period even this insufficiently rapid process of expansion of facilities came to a halt. If we also consider the rapid aging of equipment and the unavailability of spare parts and of even basic materials, it must be stated that the state of the equipment available to the Polish scientist is at present extremely poor. What is worse, this state is bound to lead to a progressive devastation of the available fixed capital. In 1980 investment outlays per employee of research center were only one-third of the outlays per employee in routine production activities -- whereas in many countries this ratio is reversed. This is all the more depressing when we consider that outlays on science are essentially marginal compared with other investment outlays by the state, while the consequences of the aging of scientific equipment may be extremely grave and longlasting.

But an increase in investment outlays on science in itself, though necessary, is not sufficient. Also indispensable are: an increase in foreign-exchange outlays, at least to an extent making possible the acquisition of indispensable spare parts and the replacement of totally worn equipment with its new counterparts; the development of domestic production of scientific equipment; the granting of priority to scientific centers in the acquisition of materials for research (usually this concerns insignificant quantities); the development of domestic production of computational and informatic equipment; and the elimination of restrictions on imports of computational equipment.

The importance of the last two points has to be stressed. Modern research techniques in the technical sciences are marked by a high degree of automation and computerization. Unless computational equipment is more widely accessible, our science will be unable to catch up with the worldwide development of research techniques.

Technological progress and cooperation with industry. In view of the conditions under which Polish science operates, it is worth stating that the level of basic research in our country is high. The contribution of Polish scientists to world science, as measured in the number of works cited by foreign authors, the number of books translated into foreign languages, and the number of invitations to lecture at foreign institutions, or the number of invitations to present papers at international conferences, is undoubtedly considerable. This is favorable testimony to the abilities, commitment and industriousness of a majority of scientists. But when we consider the economic and technological effects of scientific research, as measured in terms of, e.g., the number of applications, the conclusions are simply negative. Most of the causes of this trend are, though, not attributable to science. For science itself is incapable of forcing enterprises to undertake modernized production, altering social relations, or guaranteeing that its research findings and expertises will be considered in the taking of decisions essential to economic practice. The attribution to science of the possibility of independent implementation of extrascientific aims is a source of many misunderstandings.

The development of cooperation between science and practice requires the presence of motivation in both parties. The current system for funding science, which provides for a considerable degree of self-financing of research centers, affords motivational possibilities for the science community, but it threatens an excessive dispersal of effort on the implementation of minor commissioned projects of a sporadic nature, which harms future topics of a longrange nature. Hence the need to place greater emphasis on disciplinary research and centrally guided longrange targeted research.

Even more important is the creation of motivational mechanisms by industry. At present such mechanisms are absent. The previous command-economy system did not promote a fruitful cooperation between science and practice. The economic reform also has not so far stimulated greater demand for innovations. The introduction of the principles of autonomy, self-government and self-financing at enterprises is, to be sure, prompting enterprises to become interested in maximum profits, but given the present market disequilibrium, the far-reaching arbitrariness of price-formation, and the monopoly position of many enterprises, these profits can be achieved without requiring a rise in labor productivity or modernization of products and production processes. In addition, the absence of stable conditions for production and innovative activity favors sporadic measures that do not promote the longrange development of enteprises. Thus, in industry the demand is primarily for fragmentary research of a service-providing nature, oriented toward solving current production problems.

The development of an effective cooperation between science and industry thus requires: drafting a longrange program for the development of discrete branches of the economy; offering incentives to interest enterprises in technological and organizational progress; intensifying contacts between representatives of science and practice through, among other things, transfers of highly qualified personnel from educational and research institutions to industry; and forming a science advisory system in industry.

Also essential are questions of the position and utilization of engineering personnel in industry, as discussed earlier in the section dealing with personnel problems.

Foreign cooperation. The maintenance of manysided and systematic foreign contacts is indispensable to the development of science. Given the shortage of funds for scientific equipment and literature, international cooperation is becoming particularly essential. In many cases the conduct of specific experiments is feasible only owing to the use of facilities available at foreign centers. Given the restrictions on technological cooperation, scientific exchange is often the sole channel for the influx of new ideas from the technologically more advanced countries. The importance of international cooperation to verifying the results obtained is obvious. Hence also every support should be provided for all forms of foreign scientific cooperation, bilateral and multilateral cooperation with the socialist countries, and also cooperation with the countries of the Third World and the capitalist countries. In the case of the capitalist and Third World countries, cooperation has most often the form of individual trips abroad funded partially or completely by the inviting party. It is thus not too costly, and at the same time it affords the opportunity of contact with many leading scientific centers. Cooperation with developing countries may play a major role, by smoothing the road for Polish exports. Hence also individual trips should be supported, particularly those which are of scientific value not only to the traveler but also to the institution employing him.

Scientific publications are of basic importance to the flow of scientific information. The influx of foreign scientific publications is the least expensive and absolutely indispensable form of maintaining our ties with world science. The curtailment of this influx represents a direct threat with consequences that are difficult to repair. In particular, the cessation of the influx of periodicals whose issues have often been meticulously collected over many decades would be an irreparable loss. Isolation from world literature means an inevitable regression in development.

Of great importance also are the domestic scientific publications. They are a form of documenting our accomplishments, presenting them to the world, and elevating the prestige of Polish science, and they represent a basic means of transferring scientific achievements to economic practice. Hence it is necessary to support the domestic scientific publications in all the fields in which Polish scientists have something to say. In a situation in which Polish books are expensive, while foreign books often are virtually inaccessible to private readers, special importance is acquired by libraries, which are both the workshop of the scientist and the source of science information. Basic importance to scientific work is also acquired by the provision of efficient reproduction (xerographic) facilities.

The popularization of the achievements of science is a major prerequisite for their utilization. Here it is important to propagate the accomplishments of Polish science both to the world and among the domestic public. Worldwide dissemination is accomplished chiefly by means of scientific publications, especially periodicals. These can fulfill their proper role on condition that their high scientific level is maintained and they are published regularly. Even more important, though, is the dissemination of the obtained results within this country. This concerns, first, utilizing these results by the national economy and, second, providing decisionmakers with the information needed to take decisions. Thirdly, this concerns elevating the general technical culture of the society, which in Poland is not high. A situation in which the achievements of Polish science often are better known abroad than domestically is unacceptable. Hence also emphasis should be placed on disseminating the achievements of science by means of appropriate publications as well as of the press, radio, and television.

There exists a need to provide youth, and in the long run every member of the society, with the possibility of learning how to avail oneself of modern means of informatics, so that our citizens would be no less familiar with and competent at using these means than the citizens of other countries.

Development Directions and Priority Topics of Research

A correct strategy for development and priorities in the technical sciences must be linked closely to a longrange concept of economic development of this country and discrete branches of the economy. Such a strategy must assure narrowing the growing gap between our technology and the world level and adhering to the world level in the fields in which our current position is high.

When selecting priority directions of technology development, allowance should chiefly be made for the existing potential, available raw materials, existing technological traditions, and the needs of the developing society.

The following must be general principles for planning technology development:

-- adaptation of development plans to energy resources;

-- shifting the emphasis from high-quantity output of low-value materials- and energy-intensive products to the output of products with a high degree of processing;

-- placing stress on the development of the economic fields directly meeting consumer needs;

-- basing industrial development on the domestic resources of raw materials.

This implies the need to promote the following branches of technology:

-- coal, copper, and sulfur mining as well as the mining machinery and equipment industry;

-- chemical industry and chemical equipment industry, particularly with regard to byproduct-coke and sulfur-chemistry industries;

-- metals industry, especially high-grade and nonferrous metals subsectors;

-- electrical machinery and power equipment industry, machine tool industry;

-- shipyard industry, especially the construction and equipping of special-purpose vessels;

-- land and air transportation equipment industry;

-- electronics -- specially microelectronics -- industry, precision instruments industry, production of means of informatics;

-- industry based on programming engineering;

-- building and construction machinery industry;

-- food and agricultural industry, food and agricultural machinery and equipment industry;

-- light industry and consumer appliances industry;

-- scientific, control, and medical equipment industry.

The priority directions of research should ensue from the needs of technology development and the present state of discrete disciplines. Priority research problems may be divided into the following thematic groups:

-- methods for processing raw materials and manufacturing finished and semifinished chemicals, development of chemical and bioprocess engineering;

-- new energy sources and streamlining the processing and utilization of energy;

-- mechanics of materials and materials engineering, serving to reduce the materials-intensiveness of production and facilities and increase the durability and reliability of equipment;

-- architecture, urbanistics, and construction, for improving the country's build-up;

-- operating principles of machinery and equipment, indispensable to an efficient utilization of national wealth and to halting its accelerated decapitalization;

-- methods of environmental protection;

-- techniques of producing and processing agricultural produce;

-- electrical engineering;

-- electronics, informatics, and telecommunication;

-- automation and robotics;

-- refinements of means of transportation;

-- biomedical engineering.

The problems entailed in these basic directions, which are of fundamental importance to the future of this nation and country, must be immediately resolved.

These problems naturally transcend the domain of the technical sciences, but the universal nature of these sciences, ensuing from their role as a servant of society and of other domains of science (in which accomplishments are scored with the aid of technical sciences) cause the participation of technical sciences in the resolution of these problems to be essential. Attention should also be drawn to the need to maintain a balanced development of discrete disciplines and technical sciences as a whole. This means that prioritizing certain fields should not entail the neglect and decline of others with lower priorities. Modern technology constitutes an organism created from closely interdependent elements. There can be, for example, no development of informatics or robotics without the development of electornics, electrical engineering, and precision mechanics, and similarly advances in biotechnology would be inconceivable in the absence of chemical engineering. Maintaining a balanced development of sciences is a basic prerequisite for a correct strategy of development and priorities.

Sciences of processes and materials. In the field of thermodynamics and combustion the following research directions are expected to receive priority: 1) refinement of the thermodynamics of real factors and processes; 2) identification, refinement, and intensification of energy conversion processes in flux through machinery; 3) intensification of heat and mass transport processes; 4) research and development of combustion processes; 5) automation of research into complex heat-flux processes and systems; 6)

unconventional techniques for the identification of states of thermodynamic-flow effects and processes; 7) thermodynamics of disequilibrium processes; 8) unconventional methods for the conversion, transport, and storage of physical energy; 9) unconventional methods of combustion and gasification as well as of storage, transport and conversion of chemically bound energy.

Chemical and process engineering, being a discipline concerned with processes of conversion of matter from economically less valuable to more valuable forms, is a particularly important factor in providing the conditions for a marked increase in the degree of conversion of domestic raw materials, increase in the degree of utilization of secondary and waste materials, and development of waste-free and environmentally safe methods of industrial production.

The related priorities of research directions in Poland should comprise:

1) basic research in the fields in which Polish chemical and process engineering has scored substantial accomplishments, including:

-- dynamic processes: primarily investigation of processes of filtration, mixing, demisting, dropwise condensation, fluidized beds, and non-Newtonian flow;

-- heat kinetics and mass kinetics of inhomogeneous systems: primarily research into processes of drying, absorption, extraction, condensation, mass exchange in multicomponent and dispersed systems (droplets, bubbles, foams, porous media);

-- in reactor research: quantitative description of mixing and mass transport effects in homo- and heterogeneous flow-through reactors, further development of design and optimization techniques, research into biochemical engineering;

2) research targeted to meet the needs of basic directions of this country's economic development, including:

-- byproduct-coke industry (comprehensive utilization of coal, purification and processing of gas and liquid fractions, problems of basic synthesis);

-- thiochemical industry (evolution of sulfuric acid production technology, problems of synthesizing refined forms of sulfur, basic thiochemical syntheses);

-- industry of nitrogenous, phosphoric and potassic fertilizers, as well as the utilization of rock salt;

-- organic synthesis industry (methanol, oxidation of hydrocarbons -- cyclohexane, paraffins; phthalic and maleic anhydrides, etc.);

-- pharmaceutical industry and crop protectants industry;

-- metals industry (nonferrous metals, aluminum hydroxide);

-- electrochemistry and electrothermics;

-- biotechnology, including protein production;

-- environmental protection (especially as regards problems of the power, metals, and chemical industries).

The thematic research priorities in metallurgy are:

1) Theory of metallurgical processes: physical and thermodynamic properties of solutions of metals and fused salts; equilibrium and kinetics of metallurgical reactions in homo- and heterogeneous systems; solid- state reactions; electrochemistry of metallurgical processes; heat flux and mass flow in metallurgical processes; dynamic mathematical models of metallurgical processes as a basis for automation;

2) Metals science: processes of crystallization of metals and alloys; equilibrium systems, kinetics and mechanism of phase transitions; plastic deformation and recrystallization; theory of powder metallurgy; metallurgy of composites; alloys with special physical and chemical properties; further development of quantitative description of the texture of metals and alloys;

3) Metal casting: new casting alloys with special properties, composites; control of solidification processes; properties of castings and casting alloys; utilization of shape tenacity; investigation of physicochemical effects in the technological processes of casting (including models, molds and single-use cores); theoretical principles of new casting techniques (including casting in gravity-assisting and gravity-free fields); technologicity of the design of castings; optimization of casting processes; development of mathematical models of casting processes; design principles of new generations of casting machinery and equipment; and the automation and roboticization of labor-consuming operations;

4) Metalworking: mechanism of plastic deformation in technological processes; dynamic effects accompanying the rolling process; lubricants in metalworking technology; tube rolling.

In materials science interest is focused on special metallic and ceramic materials as well as on plastics and composites. The scientific activities undertaken by the domestic research centers are intended to promote the development of these materials, master new or improve already employed technologies of their production, and streamline their utilization.

The basis for the development of this science is to be a thorough exploration and understanding of the interrelationship and interdependence of chemical composition, internal structure, and physical and chemical properties of these materials, as well as of the raw materials and .pa
semifinished products used to produce them, with the object of mastering the possibility of purposive alteration of their properties.

Attention should be drawn to engineering studies of the useful properties of the surface layer of materials, and to the mastering and propagation of technological methods serving to improve these properties.

1) With respect to metallic materials, research should be pursued into: high-strength metals, metals with high corrosion resistance, amorphous metals, metals with special properties (shape-memory metals, ferromagnetics).

2) With respect to ceramic materials, research should be pursued into: materials for electronics (substrates, housing, active circuit elements), materials for special structural applications, for work in aggressive media and at high temperatures, materials for medical purposes (based on strong and organically neutral composites), and high-strength high-purity glasses (for broad optical applications and in telecommunications).

3) With respect to polymeric materials and plastics, priority should be given to research into: the new generation of polymeric structural materials with special properties; high-temperature dielectrics and semiconductors for microelectronics; polymers for medicine.

In connection with the materials research being undertaken, it is necessary to refine research techniques with the object of enhancing their precision and sensitivity and applying automation and computerization to the analysis and processing of findings. Considerable emphasis will be placed on applying new techniques which so far are not being sufficiently utilized in this country.

In addition, for certain new materials, research into streamlining the techniques for designing the equipment built from them is anticipated.

Of major importance to proper materials management is the development of an integrated materials information system (databank, information network).

Mechanical sciences. In the field of mechanics the following research priorities are envisaged:

1) Inelastic analysis of materials and structures. Studies should focus on developing systems for the numerical analysis of materials and structures from the standpoint of their applications in reactor technology, earth's crust mechanics, dam construction, and civil engineering mechanics. These systems should include identification of material parameters, as developed from the standpoint of applicability in computational models.

2) Modern techniques of structural design and optimization. Problems of the computerized design and optimization of engineering structures and machinery will be an important direction of research. The work in this respect will concern the optimization of structural designs with allowance for boundary and elastoplastic states, crack propagation, and three-dimensional stressed states. This work should lead to the development of computerized design and optimization systems for discrete types of structures. Problems of effective control should also be investigated with respect to engineering structures and mechanisms, particularly in robot design.

3) Mechanics of the destruction and fatigue of materials. Studies should focus on developing criteria for the initiation and propagation of macrocracks until the moment of total destruction under both variable and monotonically increasing loads. The fatigue strength of structural materials should be investigated so as to determine the conditions for the initiation and propagation of fissures.

4) Mechanics of composites. Studies should comprise fiber-reinforced materials as well as scatter-reinforced ones (fibers, intrusions, ceramic composites, etc.). In view of the spreading use of composites, the related research should be expanded and specialized research centers established.

5) Analytic mechanics oriented toward interdisciplinary engineering problems of basic and applied nature. The topics of research will be the the development and elaboration of formulas of analytic mechanics (Lagrange, Hamilton, etc.) with the object of devising coherent and uniform techniques for the construction of mathematical models of engineering systems in which effects of an interdisciplinary nature are present. The results achieved in this field are to serve as the foundation for research into the dynamics (including vibrations) of electromechanical systems, vibrations with allowance for the surrounding fluid (liquid or gas), and problems of passive and active control of systems with heterogeneous physical structure. There will be parallel development of research intended to apply to analytic mechanics modern mathematical techniques, as well as research into the stability and stabilization of the constructed models of interdisciplinary effects.

6) Mechanics of fluids and gases. External and internal flow, boundary layers for the needs of aviation, shipbuilding, mining, and the machinery and chemical industries. Multiphase and non-Newtonian modes of flow that are of current and potential importance to environmental protection, industrial and extractive technology, biology, and medicine. Modes of flow with mass and energy transfer, and chemical changes, with special allowance for the needs of the power industry and chemical engineering, stability, turbulence, and waves, and selected problems of physical and statistical hydrodynamics as well as of cold plasma which are currently under intensive research at many of the world's scientific centers.

As regards machine design, mention should be made of the following directions of research:

1) Studies of the basic theory of design processes, as based on incorporating into the design process aspects of the economics of production and operation, as well as social problems, environmental protection, etc.

2) Solution of the scientific problems of computers as an aid to machine technology and operation.

3) Development of research into the durability, reliability, and safety of machines.

4) Research into the physics of damage, that is, into the formative mechanisms of permanent deformation, brittle and ductile cracking, development of fatigue cracks, creep, and stress relaxation.

5) Development of research into the dynamics of machines (studies of dynamic characteristics of discrete system elements and integral systems as based on systems approach).

6) Studies of criteria and methods for the selection of optimal technological processes and the organization of production (including analysis of: mechanics of the processing of materials; physicochemical foundations of casting, welding, and metalworking processes; causes and conditions of the emergence of physical effects perturbing the course of technological processes; and the possibilities for new industrial applications of vibrational methods, the erosive effect of jets and fluids, the diffusive fusion of metals in a vacuum, and the utilization of the energy of the electron stream, plasma, and the laser beam).

7) Research into physical effects at interfaces between various solids and media, research into tribology and the formation of properties and structure of the surface layer, and also techniques for diagnosing the physical and useful properties of surface layers.

8) Development of techniques for experiments with and diagnostics of machines.

9) Research into micronic processes, including:

-- research into design techniques;

-- development of theoretical models and studies of positioning systems;

-- development of theoretical models of microassembly;

-- studies of micromachining effects and development of mathematical models of micromachining.

Power industry and the sciences of electrical energy. The principal directions of research into power generation should include:

1) Studies of the selection of optimal energy carriers, optimization of their use, and restructuring of the power economy.

2) Development of facilities for the conversion, transmission, distribution and utilization of fuels and energy with the object of:

-- augmenting the unit installed capacity of facilities;

-- streamlining the efficiency of energy conversion;

-- augmenting the reliability of power supply by using modernized design techniques, new materials, new technologies, and new methods for organizing production.

3) Development of new comprehensive techniques for forecasting the development of the entire economy, including integral power management.

4) Formation of a bank of technical-economic data for techniques of forecasting the power economy and optimized calculation of engineering and organizational projects under integral power management.

5) Exploration of new power technologies based on the use of domestic fuels, processes with extremal parameters, nuclear and thermonuclear processes, and new sources of renewable energy.

The electrical energy sciences and electrical engineering will play a highly essential role in the development of the directions of science and technology currently designated as the most important in this country: electronics, automation, robotics, and power generation. In the first three of these directions an essential part of modern components has to be provided by the electrical engineering industry; this includes, e.g., the electrical-machinery elements of automation. As regards power generation, the extremely costly construction of power plants and grids may be partially curtailed by developing and putting into operation -- on the basis of scientific research -- the production of energy-conserving receivers of electrical energy.

The planned development of microelectronics must be accompanied by preparing the proper utilization of electronic systems. Microprocessors will be primarily used in electrical equipment, particularly in power drives, which will require even now the conduct of intensive research.

The modernization of the electrical engineering industry requires in many fields the application of new production technologies and new designs based on basic and applied research.

Hence also the development of research into the electrical engineering sciences should be expected in the following directions:

1) electromagnetic fields -- analysis and synthesis;

2) electrical circuits -- analysis and synthesis;

3) physicochemical effects in electricity-insulating materials and systems;

4) theory and studies of the electric arc and long sparks;

5) electromechanical energy converters;

6) electromechanical energy conversion systems;

7) transmission of electrical energy;

8) electric traction;

9) electrothermics -- the electrical aspect;

10) cryoelectrics;

11) chemical sources of electrical energy -- the electrical aspect;

12) electrical illumination;

13) electrometrology;

14) curtailment of disturbances caused by electrical systems.

Electronics and telecommunications, informatics. The main directions of research into electronics and telecommunications include:

1) materials-technology research: materials and technologies of their rocessing for the needs of semiconductor microelectronics (pure silicon, acuum and derivative technologies); also highly essential are materials for optoelectronics (semiconductors, dielectrics, optical glasses, materials for image converters);

2) research into electronic components and systems: computer design and testing of integrated microcircuits, especially microprocessor circuits. Also highly essential is research into methods and systems for digital signal conversion (digital filters, image analysis, data compression, and spectra). Research into microwave structures (elements of milli-meter wave range, integrated microwave circuits, wall antennas) should be intensively continued;

3) research into optoelectronic elements and systems: fiber optics engineering (semiconductor lasers and light sensors) and the technology of integrating optoelectronic circuits (dielectric and semiconductor functional elements);

4) research into promising information and telecommunication systems: digitalization of information and telecommunication systems and fiber-optics transmission of information. Also highly essential is research into the integration of telecommunication equipment and services, including electronic switching and digital teletransmission (both hardware and software).

Emphasis should be placed on closely interrelating the priority directions of research. The results of materials-technology research will be directly utilized to develop new elements and systems. In their turn, promising systems and elements require new materials technologies.

The fact should be stressed that microprocessors and microcomputers are becoming tools used universally in R&D work in all technical and other disciplines (physics, biology, medicine, geophysics, etc.).

The exceptional significance of the spread of electronics in economic life, administration, households, and private lives should also be emphasized. For the universal spread of electronics plus telecommunications creates the technical infrastructure of the society.

When proposing basic directions of research into informatics until the year 2000 and subsequently, it should be considered that this is a field with an exceptionally rapid pace of development; this is a lively field in which many new discoveries and concepts are to be expected.

The following basic directions of research in domestic informatics may be indicated:

1) With respect to the theoretical principles of informatics, work on:

-- theory of computational processes, which includes: their mathematical models, problems of simultaneity, algorithmic and temporal logics, nonclassical theory of algorithms;

-- theory of information processing systems, which includes: principles of their design, problems of simulation and emulation, methods of effectiveness assessment, problems of the architecture and logic structure of computer systems with special consideration of paralle structures and przeplywowe machines;

-- theory of (focused and scattered) information systems pertaining to databases, expert systems, etc., and comprising techniques of inference, modification and protection of information of information ensembles, conversion of various (phonic, graphic) forms of data presentation, pattern recognition, and other problems of artificial intelligence.

2) With respect to programming, the work is directed toward:

-- development of modern techniques of program design and implementation, design of components and complementation of programming hardware and software;

-- theoretical principles and specification techniques for program conversion with retention of program contents;

-- initiation of significant experiments with nonclassical programming concepts.

3) With respect to design techniques for computers and informatics equipment, the work is being focused on:

-- principles of the structure and design of 16- and 32-bit microcomputers and minicomputers, with special consideration of personal computers;

-- standard design of an equipment assembly for constructing open-type, standard, and local-area computer networks;

-- principles and techniques of the design of peripheral equipment, and especially of equipment for so-called computer graphics;

-- principles of the assembling technology of microcomputer equipment;

-- principles and development of computer systems for the automation of the design and manufacture of modules and elements (including VLSI systems).

4) With respect to the principles and techniques of the design of computer environment, work on:

-- logic architecture of computer networks, with consideration of problems o the integrated transmission of data, voice, and images;

-- principles of theory and the hardware for automating the development, verification, implementation, and testing of communication protocols;

-- dispersed operating systems and dispersed databases.

The range of research presented above does not include research topics relating to the applications of informatics in various domains of science, technology, and the economy.

Automation and robotics, biocybernetics and biomedical engineering, metrology, acoustics. The following should be the priority directions in automation:

1) a broadly conceived control theory, and particularly:

-- theory and techniques of the design of systems with many variables, a field being very intensively developed on the world scale and in which good results and traditions obtain in this country as well;

-- theory of time-delay systems and systems with distributed parameters, in which the Polish school has attained a high international position;

-- theory of discrete-process control, with an extremely broad range of applications;

-- stochastic control theories and theories of games (significant accomplishments so far);

2) theory of hierarchic systems, a field being very intensively developed on the world scale and in which the Polish school has attained an extremely high international ranking. The application of the theory of hierarchic systems to water systems is of major importance to the national economy;

3) theory and computational techniques of optimization, which are being intensively developed on the world scale, and in which Polish accomplishments are valued by the world;

4) robotics: analysis of world technology development trends indicates that as soon as in the 1990's intelligent roads will be widely used in production and services, which necessitates initiating work on robots of this type in Poland as well.

As regards biocybernetics and medical engineering, the following directions of work may be distinguished:

1) research into biological systems, and particularly nervous and circulatory systems, focusing on studies of mechanisms underlying the foundations of learning processes, nervous-system control, techniques of signal recognition, studies of the regulatory mechanisms of blood pressure and of the stimulatory system;

2) research into techniques and systems of measurements for biomedical purposes, comprising work on new methods for obtaining information from biological signals and developing measuring converters based on new physical or physicochemical principles of action;

3) artificial internal organs: the related work comprises research into techniques and equipment for reinforcing or replacing damaged or lost functions of natural organs (kidneys, liver, pancreas, heart);

4) biomaterials: the related work concerns interaction between drugs and plastics, the development of plastics of medical quality, and the molding of plastics having desired shapes and structures. The results of such work are of major importance to the advancement of work on artificial internal organs, diagnostic devices, and implants;

5) informatics in medicine: development of computer programming for specified medical tasks (e.g., for diagnostic purposes), and development of computerized devices for the analysis of selected types of biological signals and patterns (e.g., analysis and classification of chromosomes);

6) biomechanics: the related work concerns chiefly research into mechanical properties of muscles, analysis and simulation of the movements of human appendages, techniques for the control of manipulators, robots, and mechanical vehicles, and the construction of equipment for the rehabilitation and nursing of incapacitated persons;

7) biomedical engineering in cardiology: the research subjects include diagnostic and therapeutic techniques in cardiology as based on the use of computer engineering and devices for intensive monitoring.

Work on the medical applications of lasers, thermography, cryoengineering, fiber optics, and radiation will also be developed.

Metrology as the science of measurements, whose scope comprises the theory of measurements, standards of measurements and materials, and research equipment, needs to be further developed.

It is indispensable to: develop the theory of measurements and interpretation of research findings, simulation of measurement systems, planning of experiments, and measurement techniques and procedures; intensify studies, especially in those fields of research equipment in which a groundwork has been laid for Polish scientific specialties; intensify research into standards and materials; and augment the number and range of the standards of measurements and materials.

Special attention should be paid to problems of the automation of research, and hence also to work on mathematical models of the effects measured, algorithms of mensuration processes, architecture and structures of computerized measurement systems, and problems of communication between scientific equipment and measurement systems.

The initiation of intensive scientific research into theory of measurements and the design principles of research equipment, as well as the concentration of heretofore dispersed related scientific activities requires establishing within the Polish Academy of Sciences a metrological center that could also coordinate the efforts undertaken as part of the central program for the development of the equipment and means of automating research.

Modern acoustics comprises, in addition to audible effects, problems of infra-, ultra- and hypersonics. This affords new research opportunities on the micro- and macroscale and serves to obtain a great deal of information on matter and its structure; on materials, structural elements, and the earth's crust; on living matter; on the interior of the human organism; and in underwater research. At the same time the steadily growing hazards of noise pollution represent a major social problem.

Among the basic cognitive problems in this field priority should be given to physical acoustics, and especially to quantum acoustics; the generation, reception and perception of acoustic waves and signals; and the effect of matter on wave propagation, with allowance for acoustoelectronics, acousto-optics, vibroacoustics, sonochemistry, and also psycho- and physioacoustics.

Among the applications of acoustics:

1) acoustics techniques for investigating micro- and macrostructure of materials and structural elements, comprising acoustic emission, identification of stressed states, nondestructive testing methods, studies of internal friction, and studies of the earth's crust;

2) ultrasonic and acoustic methods and equipment for medical diagnostics, including noninvasive visualization of internal body organs and blood circulation, provide quantitative information on the human organism. In addition, they allow the diagnosis and rehabilitation of vocal and auditory organs as well as of speech disturbances;

3) noise and vibration control, which includes the comprehensive problem of noise control in man's work and life environment, particularly in urbanistics, transportation, and industry;

4) analysis, conversion, encoding, transmission, synthesis, and recognition of speech, which includes interpersonal and man-machine communication, employed in telecommunications and computerization, as well as specific studies of Polish speech;

5) elevating the musical culture of this country: this includes studies of more objective techniques for evaluating auditory effects and the quality of electroacoustic equipment and musical instruments, as well as research into the acoustic design of auditoriums;

6) underwater acoustics, hydrocommunication, and sonar, which are indispensable to national defense, fisheries, and studies of water areas.

Civil and hydrotechnical engineering, architecture and urbanistics, transport. Future work in civil and hydrotechnical engineering will be affected by the present economic and ecological situation of this country as well as the prospects for its emergence from the crisis. In this connection, as regards subjects of future research, stress should be placed on the following directions:

1) engineering techniques for counteracting the growing consequences of the environmental (water, air, soil) pollution caused by conurbations and industrial activity; research into improvements of communal and industrial water supply facilities and increasing the efficiency and reliability of consumer supplies of heat energy; protection of natural environment through the utilization, proper storage and treatment of industrial wastes (e.g., wastes of the soda ash industry, phosphogypsums, open-strip mining);

2) methods for halting the aging of the engineering structures and technical infrastructure of this country (roads, railroads, sanitary installations, power networks, etc.) and methods for securing them; formulation of principles for a rational evaluation of the "lifetime" of installations; research into reliability and loss of utile properties; strength (fatigue, aging, rheology, corrosion); observations and analyses of loads;

3) research into the design and technology or production of new plastics with complex properties and exploration of constituents of such plastics; utilization of domestic raw materials and industrial wastes in construction; studies of properties of materials and their effect on the health of users;

4) formulation of principles for optimal design of structures and selection of optimal variants, upon extensive automation of the design process and tightening of assumptions relating to specifications of materials and structural elements; basing the safety margins employed on rational .pa criteria; development of the theory of design safety, including safety measures and their optimization with allowance for economic criteria;

5) studies of the development, reliability, and safety of motor highways, railroads, and urban transit; improvements in construction techniques with special allowance for energy criteria; man's effect on the natural environment; and anticipated requirements for size and efficiency of traffic;

6) streamlining of the heating of structures, with respect to both newly erected structures and those in operation;

7) streamlining of water-supply and liquid-waste management in conurbations, cities, towns, and industry, and in particular elimination of water losses and industrial multiple reuse of water.

In the field of urbanistics and architecture the tasks should be to:

1) conduct an ongoing analysis of the effect of factors decisive to the results of changes in the material environment, and hence also in the quality of life of the nation, with interdisciplinary research to pertain to boundary lines between architecture and urbanistics, on the one hand, and such fields, on the other, as agriculture, natural sciences, economics, technology--e.g., urbanistics and transport, urbanistics and water management, etc.;

2) expand studies of patterns of settlement in this country, and especially of the ongoing dispersion of built-up areas, the growth of conurbations, and the degradation of the role and territorial and social values associated with small towns;

3) work on problems of the repair and modernization of housing stock, along with studies of the social and geographical structure of cities.

In view of the ongoing degradation of the natural environment and its culture in this country, it is principally concluded that understanding the role of architecture and urbanistics in the life of nations is to be regained and that the proper conditions should be provided for this field of science and creativity, and further that the state should extend its patronage to architecture and urbanistics as an art.

Architecture and urbanistics are domains of both science and art. Their accomplishments as well as failures can be evaluated by considering the structures built so far. Conditions should be provided for promoting innovative designs, and the application of experimental solutions in housing construction should be made possible.

The scientific and research base of transportation as a scientific discipline is incommensurably small in relation to the tasks of transportation and its significance and role in Poland. There are too few institutes, researchers, and trained academics, and the research base is too tiny and technologically and organizationally inefficient, especially as regards rail transportation. There exists a need for at least doubling the scientific and research resources for solving the problems of transportation in Poland. The purpose of these resources would be to overcome the backwardness and increase

the efficiency of transport operations, as based on principles and techniques of systems analysis.

It is indispensable to conduct research in this field with respect to:

-- an integrated transport system in Poland;

-- traffic engineering (which includes the formation of a road network, a system and networks of traffic service, organization of the transport process, and the spread of means of informatics and automation within transport);

-- structure of carriers (efficient selection of means of transport, durability and reliability of these means, ergonomicity, economicality, effect of means of transport on the environment);

-- system and structure of loading and unloading carriers and their roboticization.

In view of the present and future tasks of transport, it is considered expedient to divide research problems into two groups: the first should comprise the current problems of transport, while the second, longterm group should be oriented toward the solution of problems posed to transport in the longrange concept (plan) for the development of this country.

Conclusions

1) Technical sciences are a major factor in economic development and directly influence the living standards of the society and the decline in outlays of human labor.

The accomplishments of the Polish technical sciences are recognized by world science. On the other hand, the effectiveness with which research findings are utilized is low. The scientific community is vitally interested in increasing this effectiveness, and it is responsive to the needs of the national economy.

Further advances in the technical sciences and in technology should should contribute to:

-- reducing exports of unprocessed raw materials in favor of exports of semifinished products and products with a high degree of processing;

-- reducing the energy- and materials-intensiveness of the national economy;

-- halting the process of the decapitalization of national wealth;

-- modernizing industry, and especially the machinery pool;

-- reducing the dependence on imports of products with a high degree of processing;

-- increasing exports by enhancing the competitiveness of Polish products on international markets;

-- accomplishing substantial progress in electronics, informatics, and telecommunications;

-- halting the degradation of natural and material environment;

-- adapting the range of materials produced to the needs of modern industry;

-- utilizing industrial wastes comprehensively;

-- improving the build-up pattern of this country, and improving the quality of life in cities and towns;

-- modernizing transport thoroughly;

-- adapting urbanistic structures to the consequences of the application of new production and service technologies;

-- changing the structure of industry and power generation so as to allow for the gradual depletion of this country's mineral resources and the limited economic availability of domestic and imported raw materials;

-- achieving food self-sufficiency in this country;

-- attaining substantial progress in the manufacture of durable consumer goods.

2) Following the transfer of control over the whole of science and technology policy in this country to the Committee for Science and Technology Progress, the Council for Basic Research should handle the coordination of basic research conducted in all sectors of science. The coordination of applied technology research and of its applications to economic practice, entrusted to the newly established Office for Science and Technology Progress and Applications, should be gradually refined, and it should contribute to an improved utilization of the results of scientific research in the national economy, as well as to the success of the economic reform.

3) Correct planning and guidance of the development of technical sciences should be based on a longrange concept for the social and economic development of this country, upon using techniques of systems analysis.

In their turn, plans for social and economic development should allow for the possibilities and potential of science and technology. Higher educational institutions and PAN institutes should be primarily responsible for basic research, while at the same time performing (in a suitable proportion) applied research for the needs of the national economy. Ministry institutes should primarily engage in applied research. The responsibility for training science

personnel should chiefly rest on higher educational institutions, which must be provided with the material facilities (laboratories, equipment) for the conduct of instruction at the level required by modern technology.

4) The following general principles should underlie the planning of technology development, given the country's present situation:

-- adaptation of development plans to technological and energy possibilities;

-- shifting of emphasis from high-volume output of materials- and energy-intensive products with low unit value to the manufacture of products with a high degree of processing;

-- placing emphasis on developing the fields of economy that directly meet the needs of consumers;

-- basing the development of industry on chiefly the domestic raw material resources, and strengthening cooperation with CEMA countries.

A provision should also be made for the possibility of a flexible acceleration of research in fields which may, owing to economic and technological advances. become particularly essential during a given period. The conduct of interdisciplinary research also is indispensable.

The maintenance of a balanced development of individual disciplines of the technical sciences is indispensable.

5) It is necessary to maintain the system of central planning, coordination, and administratively based funding of research, which comprises the principal long-range targeted research programs, while at the same time stimulating direct cooperation between research centers and industry. Also needed is a reduction in the bureaucracy of the management of science.

The detailed topics of research in targeted programs should be drafted from the standpoint of achieving specified targets of research rather than constituting a corpus of intentions ensuing from the interests of discrete teams.

It is worth noting that the effects of the application of recently conducted projects within targeted basic research programs markedly surpass the funds spent on that research.

It is indispensable to assure the possibility of turnover of trained personnel among research sectors and their transfers from research centers to industry. The employment of the most gifted graduates each year by higher educational institutions should be reinstated. It is desirable to expand the provision of scientific advice to economic organizations by the personnel of higher educational institutions and the PAN, and to broaden the participation of eminent practitioners in instruction at higher educational institutions. Priority should be given to the establishment of combined interministerial, PAN, and higher-education research centers for the purpose of solving problems important to the economy. Improvements in the material and housing situation

of science personnel are indispensable. Institutional conditions for a more effective development of ministry institutes should be provided.

7) It is absolutely necessary to increase spending on scientific research. The decisions already taken in this respect have been gratifying and have met with a satisfactory response. It also is indispensable to:

-- increase foreign-exchange outlays, at least to an extent assuring the acquisition of indispensable spare parts and replacement of completely worn equipment;

-- develop domestic production of scientific equipment;

-- assure for scientific centers priority in the acquisition of research materials;

-- develop domestic production of computational and informatics equipment;

-- eliminate restrictions on the imports of computational equipment.

8) The development of effective cooperation between science and practice requires:

-- drafting a longrange program for the development of discrete branches of the economy;

-- creating incentives to interest enterprises in technological and organizational progress;

-- increasing contacts between representatives of science and practice;

-- raising the prestige and improving the utilization of engineer personnel in industry.

9) Support should be given to foreign scientific cooperation, including billateral and multilateral cooperation with socialist countries, as well as cooperation with capitalist and Third World countries. Manysided and regular foreign contacts are indispensable to the development of science.

It is necessary to assure influx of foreign scientific literature (periodicals, books). The curtailment of this influx directly threatens consequences that are difficult to repair. It is necessary to preserve the printing of domestic scientific publications in all the fields in which Polish scientists have achieved valuable results.

Emphasis should also be placed on the propagation of scientific accomplishments among the society. This is an essential prerequisite for their practical utilization.

Nuclear Sciences

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[Report: "Status and Development Prospects of Atomic Energy in Poland"; (Footnote) Paper prepared for the Third Congress of Polish Science by the Atomic Energy Council and the Committee for Nuclear and Radiation Sciences, PAN]

[Text] Introduction

"Atomistics" or atomic energy is construed as the entire peaceful activity with respect to nuclear and radiation phenomena and their utilization in science, technology, and industry.

Thus this includes the basic sciences: nuclear physics, high-energy physics, thermonuclear research, nuclear chemistry, radiation chemistry, radiobiology, and also all research relating to the effect of ionizing radiation on inanimate and animate matter, which has resulted in the rise of the so-called nuclear engineering and radiation engineering, which find broad applications in economy and life. Atomistics also includes reactor physics and the complex whole of the scientific research relating to the utilization of fission energy in the nuclear power industry, along with the chemical research base of the fuel cycle.

Important fields of atomistics are: so-called nuclear safety, which concerns the correct design of nuclear power and heating plants and other large nuclear installations, in accordance with the developed requirements, as well as the construction and operation of these plants; and the radiological protection of personnel against the effect of ionizing radiation, as well as the protection of the entire population of the country against nuclear radiation and its effects.

The concept of atomistics also includes large-scale nuclear industry: the construction and operation of nuclear power and heating plants, the construction of their component elements, especially machinery and equipment, and fuel-cycle industrial plants, i.e., the production of nuclear fuel commencing with uranium ore, the processing of spent nuclear fuel, and the neutralization and storage of radioactive wastes.

Lastly, atomistics includes the so-called small nuclear industry, which comprises the production of radioactive isotopes and compounds tagged with these isotopes, as well as the production of all kinds of equipment for nuclear and radiation research and its practical applications, and also of large research facilities, e.g., particle accelerators.

Basic research into atomic energy and nuclear and radiation technologies in Poland is performed by the following centers subordinated to the State Atomic Energy Agency: the Institute of Nuclear Chemistry and Engineering in Warsaw, the Institute of Atomic Energy in Swierk, the Institute of Nuclear Physics in Krakow, the Institute of Nuclear Problems in Swierk, and the Central Radiological Protection Laboratory in Warsaw, as well as by laboratories at higher educational institutions and institutes subordinated to the Ministry of Science and Higher Education, and primarily by the Interministerial Institute of Nuclear Physics and Engineering at the AGH [Mining-Metallurgical Academy]

in Krakow, the Interministerial Institute of Radiation Engineering at the Lodz Polytechnic, the Institute of Plasma Physics and Laser-Induced Microfusion in Warsaw, and the physics departments at the Maria Curie-Sklodowska University and Warsaw University, and elsewhere.

Scientific activities relating to nuclear power generation are chiefly concentrated at, next to the aforementioned scientific institutions of the State Atomic Energy Agency and institutes subordinated to the Ministry of Mining and Power Industry: Institute of Heat Engineering in Lodz, Power Industry Institute, and Institute of Power Systems Automation. At institutes subordinated to the Ministry of Metallurgy and Machine Industry this research is concentrated at the Institute of Ferrous Metallurgy. At institutes subordinated to the Ministry of Science and Higher Education: the Warsaw, Gdansk, and Lodz polytechnics as well as at the Mining-Metallurgical Academy. Such research also is conducted at the R&D Center for Power Plant Construction, the R&D Center for Structural Reinforcements (Kielce), the ENERGOPROJEKT GBSiPE in Warsaw, and the Central Bureau for Boiler Design in Tarnowskie Gory.

A great deal of development and application work is under way at such industrial plants as FAKOP in Sosnowiec, RAFAKO in Raciborz, ZAMECH in Elblag, DOLMEL in Wroclaw, ZUT [Engineering Equipment Plant] in Zgoda-Swietochlowice, POLON ZZUJ [Amalgamated Nuclear Equipment Plants POLON], and elsewhere.

Applied research into nuclear and radiation engineering, as well as basic research, is also performed by certain centers at higher educational institutions and by institutes of the Ministry of Health and Social Welfare, such as the Institute of Oncology in Warsaw, the Institute of Labor Medicine in Lodz, the State Hygiene Laboratory in Warsaw, institutes and teams for nuclear medicine at medical academies and their clinics, and isotope laboratories at agricultural academies and institutes of the Ministry of Agriculture and Food Management and the PAN.

Representatives of these institutions take part in the activities of the Atomic Energy Council operating under the State Atomic Energy Agency, which is thus a center rallying and, in a highly general manner, coordinating activities relating to atomic energy in this country.

The main directions of development of atomic energy, as outlined during the Second Congress of Polish Science, and the directions of utilization of atomic energy in the national economy as affirmed by Decision 20 75 of the Government Presidium, have become the foundation for programs and plans for R&D work during the last 10 years.

Undoubtedly the main point of these programs was the then adopted development assumptions for the nuclear power industry, envisaging the activation of the first nuclear power plant during the years 1980-1982 and the attainment in 1990 of a capacity of at least 8,000 MW at nuclear power plants. It should be emphasized that as far back as in 1957, in the then drafted OUtline of a Longrange Plan for Nuclear Energy in Poland, the community of Polish atomic energy scientists had postulated the activation of the first nuclear power plant as early as in 1965.

Unfortunately, despite their repeated affirmation by the community of atomic scientists, these postulates were not completely carried out. This has resulted in the present difficult situation of the power industry, the entire economy and exports, which cannot be salvaged by even the maximum extraction of coal possible in our circumstances. It is to be expected that the consequences of the delay in developing nuclear power generation in Poland will be felt by our economy until the end of this century.

It was only following the adoption in 1982 by the government of the Polish People's Republic of the decision to build a nuclear power plant in Zarnowiec, and subsequent to the adoption in March 1985 of the resolution of the Council of Ministers to develop nuclear power generation (and at the same time, of the resolution of the PRL Sejm concerning the fuel-energy complex inclusive of nuclear energy), as well as upon the participation of Poland in the Comprehensive Program for Science and Technology Progress of CEMA Countries for 15-20 Years ahead, and particularly in its direction "Accelerated Development of Atomic Power Industry," that proper foundations were established for the Polish nuclear power industry, while at the same time also posing new and responsible tasks to atomistics as a whole.

Implementation of the Atomic Energy Desiderata Stated at the Second Congress of Polish Science

Basic Sciences:

Physics. Research into broadly conceived nuclear physics included topics relating to high-energy physics and the physics of elementary particles, inclusive of cosmic rays, as well as to low-energy nuclear physics. This also included studies of thermonuclear synthesis.

This research was considered among the priority directions of physics research and funded by Targeted "Key" Program 04.3 and Interministerial Program MR.I.5.

In high-energy physics and the physics of elementary particles after 1974 there occurred a vigorous worldwide development of totally new directions of research, such as research into quarks, gluons, and weak-interaction bosons. Polish physicists took a very intensive part in this research, even though it had not been envisaged in the directions recommended earlier by the Second Congress of Polish Science. In recent years, worldwide research into new kinds of elementary particles has been under way in Poland too. That research is beginning to point to a portentous synthesis of various types of interactions existing in nature. Thus this is an era of great changes in the development of physics. The nature of experimental research, too, is changing, and it requires to an even greater degree the utilization of the giant experimental facilities operated by international research centers such as the European Organization for Nuclear Research (CERN) in Geneva. In addition, a new physics discipline, relativistic nuclear physics (physics of high-energy ion interactions), has recently emerged at the boundary line between the physics of elementary particles and nuclear physics. This new discipline is practiced in Poland chiefly owing to the international cooperation at the United Institute of Nuclear Research in Dubna.

High-energy physics is at present an internationally acknowledged Polish specialty. Among the socialist countries Polish high-energy physics ranks second to the USSR, having reached its present standing owing to the rise of two strong scientific schools, one in Warsaw and the other in Krakow. The rise of these schools and the high opinion enjoyed by the works of Polish physicists made possible their access to giant accelerators at international and foreign research centers. Participation as a partner in research programs is possible owing to the construction in this country of part of the equipment for recording the effects investigated. The conducted research has produced many fundamental findings, both experimental and theoretical. For example, the discovery of hypernuclear matter in Poland has led to the rise of a new domain of nuclear physics to which thousands of studies are at present devoted and whose findings are among the subjects included in handbooks of modern physics.

During the period since the Second Congress of Polish Science the research into high-energy physics and the physics of elementary particles concerned chiefly:

-- properties of nuclear matter investigated with the aid of high-energy particles;

-- generation and spectroscopy of particles containing new heavy quarks;

-- internal structure of hadrons, manifesting itself in so-called hard collisions at high energies;

-- properties of cosmic radiation and its sources at extremely high energies.

As regards low-energy nuclear physics, the resolutions of the Second Congress postulated providing scientific centers wsith modern equipment and facilities. In this connection, the construction of two accelerator installations was undertaken: the double heavy-ion cyclotron (AIC-144) in Krakow and the heavy-ion cyclotron (U-200p) in Warsaw. The economic crisis caused the immobilization of both projects. In Krakow, tests with the internal beam are envisaged only for next year, while the construction of the cyclotron in Warsaw was resumed at a faster pace only following Resolution 120 83 of 16 September 1983 of the Council of Ministers.

Despite these difficulties Polish nuclear physics has implemented by dint of supreme effort and commitment most of its planned research projects. This was possible owing to the availability of previously trained large numbers of competent science personnel and the broad international cooperation, especially owing to participation in the work of the UINR in Dubna. Theoretical and experimental work was carried out on:

-- collective states of atomic nuclei, also in the presence of high spins and high excitation energies;

-- emission of particles from highly excited states and nuclear fission;

-- total and partial nuclear fusion as well as quasimolecular systems;

-- reaction mechanism of radiative capture of electrons;

-- deeply inelastic reactions, break-up, and transfer;

-- nuclei distant from stability path and superheavy nuclei;

-- giant resonances.

This research represents a major contribution of Polish physicists to the world science of the period. Much of it has been permanently incorporated in the monographs and handbooks on the field.

In addition, it should be stressed that both the physics of elementary particles and nuclear physics have often yielded spinoff in the form of high technology for other fields of science and for industry, as may be exemplified by the CAMAC-standard electronic systems, which have become an export item. Laboratories of physics of the atomic nucleus have been the breeding ground of such new domains of engineering physics in Poland as reactor physics, hot-plasma physics, accelerator physics, and nuclear geophysics. These laboratories have also cultivated various nuclear techniques New to Poland (e.g., neutronography, Mossbauer spectroscopy, etc.) which are widely employed in various sciences and technology. Significant results were obtained as regards the application of techniques of nuclear physics to research into the structure and dynamics of solids, fluids, and liquid crystals. Work has been initiated to apply magnetic nuclear resonance in medical diagnostics.

Research into plasma physics and controlled thermonuclear fusion, which in Poland commenced in the late 1950's, is directed toward the pulsed generation of ultradense and hot plasma in high-current discharges in experiments of the plasma-focus and ion-implosion type, conducted with the aid of lasers and explosions. The human and material resources committed to this research allow independent implementation of significant research programs as well as major international cooperation, in particular with USSR institutes under agreements between the PAN and the USSR Academy of Sciences as well as under the CEMA program.

In assessing the accomplishments of recent years, mention should be made of:

-- attainment of original findings in research into laser-induced fusion, in cooperation with the USSR;

-- solution of the problem of generating intense oriented ion jets under the so-called SOWA program;

-- development and application of hot- and dense-plasma diagnostic equipment meeting world standards, and the recent inclusion of diagnostic measurements in the CEMA-coordinated program for research into TOKAMAK systems;

-- construction of one of the world's largest currently operating plasma-focus facilities, which generates intense neutron pulses.

Chemistry. Research into nuclear and radiation chemistry was and is conducted on Poland on a much smaller scale, in the absence of the hot-chamber installations postulated by the Second Congress of Polish Science. These installations would make it possible to conduct more substantive research into radiochemistry as a basis for the fuel cycle. The equipment available to radiation chemistry teams has been expanded owing to the possibility of spectroscopic measurements at liquid-helium temperature, but the new accelerator installed at the MITR PL [Interministerial Institute of Radiation Engineering, Lodz Polytechnic] was put into operation as late as in 1984. However, basic research projects as well as projects to explore future applications were carried out in not only the former but also the latter of these research directions.

Radiochemical research concerned:

-- chemistry of the lanthanides;

-- nature of bonding in compounds of transuranium elements;

-- crystallochemistry and magnetic properties of complexes of uranium and neptunium as well as chemical properties of mendelevium;

-- refinement of separation techniques.

As regards applied radiochemistry -- the basis for the fuel cycle -- the work to isolate uranium from ores has unfortunately been almost completely abandoned, as has been the work on fuel materials, in particular on the chemistry of plutonium compounds. Model work has been carried out on certain aspects of spent-fuel processing (in particular, extremely good results have been obtained in pioneering work on rapid techniques for the extraction of spent fuel), on the isolation and properties of certain fission products, and on radiochemical methods for determining the degree to which fuel is spent.

Interesting results have also been obtained in utilizing radionuclides in research into the mechanisms of isotopic exchange and processes of the diffusion of isotopic tracers in solutions, as well as in studies of the structure and mechanism of exchange in metal complexes, etc.

In the field of radiation chemistry the most interesting projects concerned:

-- radiolysis of inorganic and organic frozen systems;

-- an original intrinsic model of charge transport in the frozen phase, based on the tunnel mechanism;

-- an original model for the solvation of electrons;

-- development of theoretical models of localized states of electrons in amorphous and other centers.

As regards the radiation chemistry of aqueous solutions, the pulsed-radiolysis technique was used to investigate the properties and mechanism of the trapping of electrons in crystalline systems and the complex compounds of the platinides and transition metals. Significant accomplishments were scored in research into ion-molecule reactions in gases as based on a unique domestically constructed high-pressure mass spectrometer. Studies of the effect of ionizing radiation on polymers, as well as studies of mechanisms of the radiolysis of model food systems, were conducted on a limited scale.

Many of the findings of the abovementioned studies have become a permanent part of world literature, and their authors are considered to be among the world's leading researchers.

Although radiobiology was hardly mentioned at all at the Second Congress of Polish Science, the related research was intensive and fruitful. It was conducted at centers in Warsaw, Lodz, Poznan, and several other places, and it dealt with nearly all the principal aspects of radiobiology. The topics worked on were the genetic mechanisms accounting for the reduced (or enhanced) radiation susceptibility of cells cultivated in vitro, postradiation damage to the apparatus of protein biosynthesis, and cracks and other changes in chromosome structures exposed to gamma-radiation fields; the last-named research provided the foundations for sensitive biological dosimetry of doses absorbed by the human organism. Somatic effects of radiation were investigated both in the integral organism and at the molecular level. Interesting findings were obtained, particularly as regards the exploration of changes occurring within a protein molecule under the influence of high doses of radiation. Many studies dealt with the so-called delayed effects of radiation, and the Polish laboratories working on these problems became part of a special European study group. Also investigated were the acute consequences of exposure to large radiation doses, the so-called radiation sickness, and the results produced by research into the participation of coagulation processes gained broad worldwide recognition.

Also developed was radiobiological pretherapeutic research employing a neutron beam from the K-120 cyclotron, one of the world's eight centers of neutron therapy.

However, this gratifying development of radiobiological research in the 1960's came to a halt in the late 1970's and early 1980's. In recent times a marked shortage of personnel in this field has arisen.

Summing up basic work on atomic energy after the Second Congress of Polish Science, it can be stated that, following a relatively brief period of rapid advances, and following some improvements in the supply of imported equipment

during the years 1972-1975, further development was halted in the second half of the 1970's owing to the absence of equipment accessories and the depreciation of the equipment used (its overall extent of wear averages about 80 percent). This concerns both the first EWA reactor and all the larger installations (accelerators in Krakow and Warsaw), as well as the computational centers for scientific laboratory equipment and the aforementioned main computational center [as published]. As regards availability of equipment we are at present in a worse situation than we had been during the period of the Second Congress of Polish Science. And considering the advances achieved in the meantime in the highly developed countries, the gap separating Polish basic research in atomic energy from the world's research lead has unfortunately widened. In certain directions of research good contacts are maintained with foreign centers, and attempts are made to utilize their resources to develop Polish research, which alleviates our situation somewhat, but this cannot continue in the long run.

Research into nuclear power generation. The recommendations of the Second Congress of Polish Science for research into the then anticipated construction of nuclear power stations as early as in the 1970's and for the attainment as early as in 1990 of an installed capacity of about 8,000 MW, postulated research into reactor physics, nuclear safety, mastering of modern technologies of the metallurgical industry (special steels), construction industry (special concretes), and the control and dosimetric systems indispensable to the construction of these stations. At the same time, envisaging a rapid growth of our nuclear power industry, the continuation and even intensification of research into the fuel cycle was postulated. It was expected that, once the MARIA reactor is built, it could be rapidly provided with the equipment needed to initiate experimental research into reactor materials and nuclear safety.

This scope of expectations discussed and agreed upon at the Second Congress of Polish Science was implemented only to a small degree, because the absence of a decision to commence the construction of nuclear power stations placed under a question mark the expediency of initiating many research projects. The shortage of investment funds for equipping the MARIA reactor postponed considerably the implementation of research into materials and models of nuclear power stations, despite the fact that in the meantime government agreements with the Soviet Union for the joint conduct of specific research programs had been signed.

However, the conduct of domestic research and cooperation with other countries and the International Atomic Energy Agency resulted in the training of a large group of specialists during that period.

Still, the dilatory preparations for the introduction of the nuclear power industry, combined with the absence of specific measures to build the first nuclear power station despite the approved plans, affected adversely the personnel of R&D organizations who, in view of the lack of prospects, in many cases opted for changes in career and other workplaces. Such a situation led to the abandonment of certain already well-developed directions of activity considered important by the Second Congress of Polish Science, such as, e.g., sodium-cooled fast-neutron reactors, certain elements of the fuel cycle, and the programming of nuclear power generation.

Despite the losses thus sustained in the period following the Second Congress, considerable R&D and, this being highly important, industrial potential was preserved. This makes it possible to commit that potential to the initiated introduction of nuclear power generation. The results produced in this respect include:

-- preparation of numerous computational programs relating to the physics and technology of power reactors;

-- computations, design and commencement of construction of the EJ model-research installation at the MARIA reactor;

-- commencement of construction of the PUMA loop installation at the MARIA reactor;

-- preliminary design work on a nuclear heating plant;

-- numerous laboratory studies of the neutralization and storage of radioactive wastes;

-- design-and-technology and adaptation studies relating to the already initiated domestic export production, within the framework of CEMA, of heat exchangers and pressure stabilizers for WWER-440 [pressurized water-cooled power reactor] units, 2.8 and 6.2 MW emergency current generators of the Diesel type, and HINDUKUSZ intracore measurement systems and SEJWAL dosimetric measurement systems;

-- development of a technology for recovering uranium from phosphoric acid.

In recent times considerable work was done to draft basic legislation governing the whole of matters relating to atomistics, and particularly to the nuclear power industry, with a draft of a decree on "Atomic Law" having been prepared. At the same time, a number of implementing regulations meeting the needs of industry, state monitoring of nuclear safety, and radiological protection is being drafted. These regulations specify requirements and criteria, along with recommendations for meeting them, concerning materials, equipment, systems, and the construction of nuclear power stations. They are designed to apply to the entire process of establishment of nuclear power stations, i.e., to siting, design, activation, operation, and shutdown. Mention should be made of the important contribution made to drafting these documents by the R&D establishment within the framework of the INTERATOMENERGO International Economic Union.

The already existing domestic science and technology resources and industrial resources are such as to warrant considerable domestic participation in the construction of nuclear power stations and can provide a large part of the funds needed to import the necessary facilities out of the funds earned from exports of facilities. Poland's own participation in .pa
the construction of successive nuclear power reactor units
should increase rapidly.

Research centers have been cooperating for years with their counterparts in the socialist and Western countries. This cooperation allows keeping track of the worldwide development of nuclear power industry and establishing direct cooperation in many fields. This cooperation is in many cases based on mutual advantage and demonstrates that our achievements in selected problems are at the world level. This concerns particularly reactor physics and engineering, as well as selected technologies of the fuel cycle.

Nuclear and radiation engineering. The utilization of nuclear and radiation engineering in industry, including raw materials industry, as well as in medicine, agriculture, and environmental protection, was a field for which the Second Congress of Polish Science had postulated extremely rapid development and spread of its applications in the sense that it produces produces very rapidly measurable economic effects and represents considerable technological progress. The Congress postulated the development of tracer techniques for the optimization of technological processes, radiometric analytic techniques for purposes of chiefly trace analysis and on-line analysis in industry, and radiometric techniques of materials research, such as neutronography, autoradiography, nuclear spectrometry, etc. The Congress also postulated the initiation of broad-scale work to introduce radiation techniques into industry and to expand the application of radiation and tracer techniques in agriculture so as to optimize the application of artificial fertilizers, develop new crop varieties, preserve food, and disinfect grain.

In medicine -- although this was not explicitly considered in the materials of the Second Congress of Polish Science -- the need to employ electron accelerators in the treatment of malignant neoplasms and sterilization of utensils was pointed out, and a broader application of radioactive isotopes and of the compounds tagged with them in diagnosis and treatment was postulated. A broader participation of radiometric techniques in pollution identification and of nuclear devices in monitoring was seen as a way of promoting environmental protection.

The accomplishment of these aims was linked to the postulate of a marked broadening of the range of the radioactive isotopes produced in this country, in the form of both sealed sources for industry and bare sources for, in particular, medicine, in which radioimmunological techniques began to be universally used abroad. This entailed a need to modernize the EWA reactor, equip suitably the MARIA reactor, and expand the then Isotope Production and Distribution Laboratory at the Institute of Nuclear Research in Swierk. Not one of these aims was accomplished. (Footnote) (By its Decision No 49 85 of 3 June 1985 the Government Presidium accepted a program for modernizing the facilities of the Reactor and Isotope Production Laboratory in Swierk, at the Institute of Atomic Energy, and allocated for this purpose a budget subsidy of 3,590 million zlotys for the 1985-1989 period.)

Techniques of industrial testing based on nuclear technology were introduced and are being applied independently or in cooperation with nuclear research centers by the following institutions:

-- Maritime Institute, for research into marine engines;

-- Aviation Institute, for research into aircraft engines;

-- Starachowice Truck Factory, for research into automotive engines;

-- Poznan Polytechnic, for research into agricultural machinery;

-- Mazowsze Petroleum Refinery, for research into crude petroleum refining processes;

-- Institute of Nonferrous Metals and organizations subordinate to the KGHM in Lublin;

-- Institute of Electronic Materials, electronic materials industry, and many others.

Radiometric techniques of chemical analysis are employed in the zinc and lead industry (flotation control), in the copper industry (yield monitoring; in environmental protection (dust pollution, chemical composition of pollutants), and also in biological and physiological research (tagging of trace elements).

Significant results were produced by the application of nuclear devices in geophysics. Several versions of gamma-radiation drill spectrometers serving to intensify prospecting for black coal, sulfur, and nonferrous metals were developed. Radioisotope techniques for the needs of the so-called isotopic hydrology, suitable for forecasting flooding in mines, were introduced in Poland.

A large variety of highly reliable radioisotope relays, densitometers, isotopic scales, soil densitometers, etc., was developed and introduced. Unfortunately, many of these projects could not be widely applied in practice to meet the country's needs, owing to the underinvestment in plants manufacturing nuclear devices and, as a consequence, the absence of expansion of their productive capacity.

Research into plasma physics and thermonuclear fusion has been a stimulus to the development of many subtle measurement techniques and modern technologies. This includes in particular:

-- unique noncooled infrared sensors (exported to socialist and capitalist countries);

-- the IONOTRON, a facility based entirely on Polish scientific and technical thought: it generates short pulses of ion jets with instantaneous power of the order of gigawatts, which found application in pulsed implantation and modification of the properties of material surfaces;

-- measuring lasers, laser components, and laser technologies (micromachining tools, lidars, etc.);

-- pulsed high-voltage and high-current generators.

Interesting results were obtained as regards radiation engineering. Irradiation was used as a way of producing heat-shrinkable plastics, thermosetting pipe for the cable industry, and thermosetting strip, of interest to mining and other industries. Pilot production was commenced in Warsaw, while industry itself put into operation a complete production line at the Technology Equipment Plant in Czluchow, with the country's first accelerator (still an import from the USSR) to be incorporated in an industrial production line there.

Undoubtedly, a highly positive role in the development of nuclear engineering within the nuclear sector was played by Key Program 04.3, "Nuclear Research and the Application of Nuclear Engineering to the Country's Socioeconomic Development," which integrates within a single coordinating plan both basic and applied research.

Significant results were achieved in medicine, on initiating the production of accelerators for cancer treatment in cooperation with the French company CGR-MeV, under the aegis of Government Program PR-6, "The Fight Against Cancer Diseases." By now 10 such NEPTUN-10p accelerators are operated in Polish hospitals, with 20 others having been exported to France, the GDR, the Hungarian People's Republic, and Bulgaria. A subsequent effect was mastering the domestic production of accelerating structures of the standing-wave type (not included in the cooperation agreement) and the recent construction and tests of an entirely Polish-designed accelerator, the LIMEX (4 Mev), also for cancer treatment (replacing the cobalt bomb). Both accelerators may also be produced in an industrial version for radiography.

Progress, far though it may be from meeting the needs, has also been achieved in the manufacture of kits for radioimmunological testing as well as of other bare sources for medicine. The first steps in this field were made efficiently, by introducing for use technetium-type generators and generator assemblies, but, after the most urgent needs had been met, this work was halted. Somewhat later, the introduction of radioimmunological techniques in laboratory analysis was commenced, and this field developed rapidly. The availability of radioimmunological kits became a stimulus for the formation of new radioimmunological analysis laboratories. At present, about one-half of all radioimmunological kits in Poland is being manufactured in Swierk, and Poland has become their largest producer among the CEMA countries. The further development of these fields requires an assured supply of radioactive isotopes with extremely high specific activities, and this in its turn requires modernizing the EWA reactor, equipping properly the MARIA reactor, and expanding the Reactor and Isotope Production Laboratory in Swierk. Not one of these aims has been accomplished, though they were postulated several years ago.

Similarly, the application of nuclear and radiation technologies to agriculture produced results during the period considered. At several centers research into keeping food and feeds fresh by means of irradiation was conducted, and preparations were made to build and equip a pilot plant. Radiative mutagenesis was investigated, and varieties deserving propagation were developed. Work also was undertaken on techniques of pest control based on radiation-induced sterilization, as well as on the utilization of municipal and farm wastes. Tagged-atom and isotope techniques also were applied to optimizing crop fertilization as well as to work on livestock breeding. But the application of the results of research work has been rather distant from the needs and the potential for their utilization.

Work on radiological protection. This work has been pursued in the direction of developing practical techniques of the radiological protection of occupationally exposed personnel as well as of all persons in contact with radioactive sources. Also investigated were the state and dynamics of the distribution of radioactive isotopes in the biosphere in Poland and abroad as well as the cumulative doses absorbed by selected employee groups and the population doses in Poland. The findings were utilized in many international studies, including those of the United Nations.

In all these directions, work on radiation dosimetry and metrology was accompanied by efforts to recruit young personnel for this field, despite the considerable difficulties involved, in view of the major numerical decline in trained personnel during the last few years. The shortage of radiological protection personnel also exists outside Poland. The absence of this area of study in the curriculums of higher education creates among youth the feeling that this is an inferior occupation, thus detracting from its popularity.

Significant results have been achieved with regard to dosimetric techniques of evaluating the irradiation of personnel, the global radionuclide pollution, the contamination of the population by natural sources, the coal-burning power industry, and the uses of x-radiation in medicine.

Summing up the status of atomistics following the Second Congress of Polish Science, the following may be stated:

-- in nuclear power generation the lengthy postponement of the decision to build the first nuclear power station and the absence of needed investments in institutes caused a slowdown in the pace of related research; this has not, however, affected the work relating to the commencement of the industrial production of exportable equipment for WWER-440 [pressurized water-cooled reactor] power plants, built under agreements with CEMA;

-- the domestic scientific base of atomistics has, on the other, had continued its research work with positive results and it also has been working on applications of nuclear and radiation techniques to the economy, medicine, environmental protection, etc.; further, it has engaged in basic research into nuclear physics, high energies, plasma physics, thermonuclear fusion, nuclear and radiation chemistry, and radiobiology; in addition, it has developed many successful types of nuclear and electronic equipment, which also are being

exported. It is a pity that the unavailability of even relatively small investment funds has made it impossible to multiply output and exports.

Postulated Development of Atomistics Until the Year 2000

Atomistics has, as known, in the years since World War II played in the entire highly industrialized world a tremendous role as a bearer of technological progress in industry and entire national economies, and also in the development of the basic exact sciences. The construction of increasingly larger and more powerful particle accelerators yields tools enabling us to come increasingly closer to exploring the real structure of matter.

Nuclear power generation has already been accepted in a majority of the industrialized countries, and the absence of its role in Poland has already been mentioned. It is to be expected that this lag will be systematically overcome.

In nuclear and radiation engineering the brunt of the effort should be focused on broadening the applications. For these types of engineering play an important role in elevating the country's technical infrastructure and facilitate or even make possible the attainment of many of the currently posed basic development goals for this country. What is more, these types of engineering are highly profitable. An analysis performed in 1983 by the Permanent CEMA Commission for the Peaceful Uses of Atomic Energy, and also by the International Atomic Energy Agency, showed that the ratio of yearly economic effects produced by the industrial application of nuclear engineering in the CEMA countries to the outlays on developing the techniques applied, acquiring equipment and performing the research relating to the full cycle of development, is expressed by a factor of 8.0-9.0. Instances in which this factor reaches 30 are known. If proper conditions for application are provided, the attainment of even better economic effects is feasible.

Our economy still does not adequately exploit the potential of atomistics. This is due to both the underinvestment in atomistics, which was completely ignored in the investment projects of the 1970's, and to the reluctance of industry to introduce innovations. We have extremely good cadres of experts, both scientists and engineers, technicians, and skilled workers, but in recent years their numbers have markedly declined. Even so, they still undoubtedly are capable of training their successors. In such a situation the recruitment of youth for this field is an immeasurably urgent matter. We lack a production base that could duplicate the existing types of small-series production in quantities sufficient for this country as well as for exports, which are feasible in significant quantities with respect to many items.

Ensuing from these general assumptions, the directions of action expedient for Polish atomistics in the near and far future are discussed below.

Basic Sciences

Nuclear physics, high-energy physics, and thermonuclear fusion. In physics of elementary particles, which is of fundamental cognitive importance to all natural sciences, current research into elementary and nuclear interactions should be continued, on devoting increasing attention and resources to major

research programs associated with the great international centers. Such programs include those based on the currently built LEP and HERA accelerators, in which Polish physicists are taking a creative part.

Experimental research into high-energy particle interactions should be conducted, particularly into those serving to explore the quark-parton structure of hadrons, as well as into properties of leptons. New elementary constituents of matter (e.g., quark-gluon plasma) should be explored. In connection with the international effort and concentration of research based on using the currently built new-generation accelerators, it is particularly important to prepare and conduct experiments in the following directions:

-- electron-positon and electron-proton interactions;

-- hadron-hadron interactions;

-- interactions between hadrons and leptons and nuclei, and nucleus-nucleus interactions.

It should be emphasized that this research includes experiments, measurement and interpretation studies, and theory.

In connection with the construction of new centers for particle acceleration abroad, the participation of Polish teams in next-generation experiments should be planned. The present economic potential of this country does not warrant postulating the construction of a high-energy accelerator in Poland, but there is a need for a radical improvement in the supply of equipment, as well as of materials for constructing equipment in this country. Computational equipment and improvements in the state of scientific information also are needed.

The research into cosmic radiation performed at the Lodz center should be continued fruitfully and at a high European level. This research concerns problems of the physics of elementary particles and space physics, two fields of physics of a particular cognitive importance at present.

Low-energy nuclear physics has not only great cognitive importance but also practical importance, particularly at present in the era of the development of nuclear energy and applications of techniques of nuclear physics to other fields of physics, natural sciences, industry, medicine, agriculture, and environmental protection.

In consonance with the world trends of science, the research conducted into the properties of nuclear matter and atomic nuclei should be continued on the basis of heavy-ion accelerators. This research will be provided with a solid base and can be intensified once the U-200 cyclotron in Warsaw and the AIC 144 cyclotron in Krakow are put into operation. In connection with the construction of new-generation heavy-ion accelerators at foreign national and international centers (intermediate and high energies, acceleration of superheavy nuclei, collecting rings, cooled beams of arbitrarily heavy ions completely stripped of electrons), plans should be made for the participation of Polish scientists in experiments on these accelerators. As with respect to

high-energy physics, the economic potential of this country does not warrant postulating the construction of a new-generation accelerator in the next 15 years.

The following should be considered particularly important research topics:

-- experimental research into the structure, shapes, and density distribution of nuclei, as well as into density of nuclear matter, over a broad range of spins and excitation energies (up to the extremal levels);

-- studies of mechanisms of nuclear reactions induced by nucleons and heavier nuclear particles;

-- parallel theoretical search for an equation of state of nuclear matter in various domains of excitation and density, with astrophysical implications;

-- studies of dynamics of collisions of multinucleon nuclei over a broad energy range;

-- elucidation of the implication of the quark structure of nucleons to the structure of nuclei;

-- research into atomic effects in the presence of heavy-ion collisions, with special allowance for extremal effects of the electrical fields generated by these collisions.

Research into fundamental problems of theory, whose standing in Poland is quite good, should be continued and developed. The existing teams should be provided with the necessary conditions for continuing their research at the highest world level in such fields as the general theory of relativity (with special allowance for gravity problems), quantum chromodynamics and problems of "Grand Unification," quantum electrodynamics, statistical physics, etc. The whole of this research at present is a central problem of the natural sciences.

The program for further development of research into plasma physics and thermonuclear fusion assumes that cognitive research into plasma systems in this country will be continued at the average world level. Our measures should be intended to:

-- continue those research projects in which we have scored original accomplishments and, at least during the stage of experiment, we can be competitive with foreign centers;

-- place special emphasis on those results of the overall program which can even now be applied in industry, and which in the future may represent our specialty under the world program for the thermonuclear power industry;

-- as part of international cooperation, initiate research into subjects that are consonant with the worldwide trends and at the same time suit the specific nature of our economy and utilize maximally our experience.

Bearing the above in mind, the continuation of domestic research and international scientific cooperation is assumed with respect to:

-- research into the inducement of fusion with the aid of medium-system lasers in this country and large-system lasers of the DELFIN family in Moscow;

-- participation in CEMA plasma research at TOKAMAK T-15 and OTR (experimental thermonuclear reactor) facilities;

-- fusion based on principles of ion optics (SOWA program);

-- generation of strong neutron pulses in high-temperature dense plasma generated by high-current discharges in plasma-focus type experiments.

The implementation of the national program for plasma research would benefit from establishing cooperation with leading centers in the countries of West Europe as well, at which thermonuclear research is under way on a large scale.

Nuclear and radiation chemistry. \In the field of basic and applied radiochemistry, cognitive research should be conducted in the following directions:

-- in connection with the operation of nuclear power stations, techniques for the analysis of fission products in aqueous solutions should be developed, as should be techniques for the elimination of these products from cooling-water circuits and reactor wastes;

-- techniques of isolating cyclotron radionuclides and developing isotopic tracers with extremely high specific activities for the needs of nuclear medicine, biotechnology, and classical technology;

-- synthesis of new compounds and studies of the properties and structure of actinide and lanthanide complexes;

-- development, refinement, and automation of equipment for separating radionuclides of actinides, rare earths, and spent reactor fuel;

-- application of isotopic techniques to research into reaction mechanisms and structure of chemical compounds;

-- investigation of processes employed in environmental protection by means of isotopic techniques.

As regards radiation chemistry, for the next few years priority should be given to the following directions of research:

-- development and computerization of pulsed radiolysis equipment on the nano- and picosecond scale, and application of this technique to research into primary and secondary processes in simple and complex model systems with allowance for biological and polymeric compounds;

-- development and computerization of radiation cryochemistry at temperatures reaching that of liquid helium, and its application to studies of processes of load stabilization and changes in radicals within frozen matrices of varied structure;

-- studies of transient ion and radical products as well as of highly excited states in the course of the radiolysis of simple and complex systems in the condensed and gaseous phases.

Microbiology. From the standpoint of present and longrange needs of this country, research should be continued in:

-- early and late postradiative changes and their formative mechanisms at the molecular and cellular levels, especially changes in the genetic apparatus of the cell, processes of regeneration, neoplasmic transformation;

-- radiotoxicology of mammals, techniques for detecting and eliminating the contamination of organisms, studies of chemical and cytological indicators of postradiative injury, and ways of modifying the course of radiation sickness.

Directions of scientific work on nuclear power industry. The program for the development of nuclear power industry in Poland until the year 2000, as drafted by the Ministry of Mining and Power Industry and discussed and approved by the Sejm, assumes that by 1990 the installed capacity of nuclear power stations will reach 465 MW (first section of the Zarnowiec Nuclear Power Plant); by 1995, it will reach 2,860 MW; and by the year 2000 installed capacity for the generation of nuclear power should, in accord with the Sejm resolution, reach 9,860 MW, or about 15 percent of total installed power generating capacity in Poland.

The principal type of power reactor to be installed in our nuclear power stations, at least until the year 2020, will be the WWER-440 and WWER-1000 water-cooled pressurized reactors. It is forecast that in the years 2000-2020 it will be necessary the expand the installed capacity of the nuclear power industry to at least 25,000-30,000 MW.

The program also envisages the construction of nuclear heating plants. By the year 2000 two units with a capacity of 500 MW each are to be put into operation. They will be equipped with AST-500 type Soviet thermal reactors.

The entire atomic energy community welcomes with special satisfaction these official data, because they represent the beginning of the implementation of a program which, according to our knowledge and conviction, is the sole longrange solution assuring sufficient power generation for our economy and life and constituting as well the first major step in the direction of curtailing the further pollution of our environment.

The atomic energy community believes that the specific features of the power generation by nuclear reactors require a qualitatively new approach to all stages of the design and construction of the equipment of nuclear power plants, and of the construction and operation of these plants. The need to introduce in this country such a huge program for nuclear power requires huge commitment of not only industrial potential to the acceptance and application of new technologies and designs but also, and above all, of R&D potential for the development of these technologies. The implementation of this extremely ambitious program requires immediate effective measures to organize the funding of research work on nuclear power industry; it also requires the granting of special priorities to the R&D sector so as to attain a state of preparation serving to put into operation one 1,000 MW unit annually in the 1990's.

The succesful accomplishment of this program will require of the R&D sector in the next few years the intensification and expansion of the R&D work relating chiefly to the construction and operation of nuclear power plants, nuclear thermoelectric power plants, and nuclear heating plants in this country, as well as relating to projects of a longrange nature, such as fast-neutron, high-temperature, fuel-cycle, and other reactors.

The following may be regarded as the principal directions of research:

-- work on scientific and technical aspects of the construction, start-up and operation of the nuclear electric and thermoelectric power plants built in this country;

-- development of technologies and commencement of the production of metallurgical material and products with properties meeting the requirements posed for machinery and equipment to be used in nuclear power generation, as well as expansion of research facilities to an extent assuring the monitoring and certification of these properties;

-- development of research test stands serving to determine the actual specifications of the equipment and machinery built, and development of techniques for operational tests;

-- research, adaptation, and application work relating to the preparation of the production of machinery, equipment, and systems for power stations operating WWER-1000 reactors;

-- development of modern construction and installation technologies employing, e.g., stressed concretes, austenitic-steel welding of linings and tubing, etc.;

-- development of modern control and safety systems for nuclear power plants;

-- development of data for optimal and safe operation of nuclear power plants based on WWER-440 and WWER-1000 reactors;

-- research to increase knowledge and engineering interpretation of effects influencing the course of eventual breakdowns in nuclear power stations, and the development of analytic techniques serving to assess nuclear safety;

-- development and introduction of techniques for neutralizing and properly storing nuclear wastes;

-- studies of the fuel cycle for nuclear power generation as regards uranium processing, fuel production, and the processing of spent fuel;

-- work on the introduction of nuclear power and heating plants in this country;

-- work on the next generation of fast-neutron power reactors, and on utilizing the heat of high-temperature nuclear reactors in technological processes;

-- tightening of the state's supervision of nuclear safety at power stations, inclusive of analyses of the safety of facilities and effectiveness of the adopted technological solutions, including the drafting of regulations and requirements for nuclear safety and radiological protection;

-- development of modern programs and techniques for training personnel for the construction and operation of nuclear power stations.

Nuclear and radiation techniques. Industrial applications. Nuclear and radiation techniques are particularly suitable for a rapid attainment of results in the principal tasks currently posed to industry, namely: improving the quality of materials and other products, reducing materials-intensiveness, increasing the productivity of technological processes, and improving the quality of production. To this end, the following techniques should be especially developed:

-- computerized tagging methods for tracking the course of technological processes, combined with the optimization of these processes and of the facilities in which they are conducted;

-- radiographic, neutronographic, autoradiographic, nuclearspectroscopic, and other similar techniques of materials research, particularly in the electronic and metallurgical industries;

-- radiometric techniques for assaying the chemical composition of raw materials and products, and particularly the composition of intermediate products during technological processes (on-line techniques), to be eventually integrated with computerized automatic production control systems;

-- radiometric geophysical techniques for the needs of the geological services;

-- tracer techniques for investigating the wear of materials in motors and machinery, especially agricultural;

-- nuclear techniques for investigating the composition of surfaces and surface layers for the needs of, in particular, the electronic, metallurgical, catalyst, and other industries;

-- radiometric monitoring techniques for environmental protection, especially for testing air and water;

-- activation techniques for synthesizing doped materials.

Radiation techniques should be consistently incorporated in industry as acknowledged technological processes. To this end, it is necessary to develop:

-- production of thermosetting materials with special (e.g., noncombustible) properties;

-- improvements in the insulation of electrical cable and conductors;

-- techniques for modifying and hardening polyester resins;

-- synthesis of polymeric materials with desired dielectric properties, polymer foams, semipermeable materials for the needs of electronics, new materials for nuclear power industry;

-- hardening and modification of coating materials;

-- improvements in packaging foils;

-- synthesis of bioactive polymeric materials for medical purposes;

-- methods for modifying plastic vascular and other prostheses;

-- new techniques for radiative sterilization;

-- purification of liquid wastes and utilization of liquid-waste sediments and agricultural wastes;

-- methods for the radiative modification of semiconductor materials.

Medical applications. The applications of nuclear and radiation techniques in medicine occur in three basic directions:

-- use of accelerators for megavolt therapy of malignant neoplasms, irradiation with high-intensity X-rays, as well as with neutrons generated in a cyclotron;

-- application of radioactive isotopes, especially the short-lived ones, as well as of tagged compounds, in medical diagnosis;

-- use of radioactive isotopes in therapy.

In all the above directions the tasks of atomistics lie in the development of accelerators and techniques for their use,as well as in the development of methods for the production of radioactive isotopes, generators of these isotopes, and the compounds tagged with them. All this work, in the form of research and application programs, must be undertaken and performed on the basis of close cooperation between the concerned medical centers and the centers for atomistics. A prerequisite for success in this field is the aforementioned need to expand the production and improve the quality of the equipment for and kits of radioactive isotopes.

Agricultural applications. The application of nuclear and radiation techniques to agriculture requires continuing and expanding research in the following directions:

-- radiative preservation of food and feeds (curtailment of losses and improvement in hygiene);

-- development of new crop varieties by means of radiative mutagenesis;

-- use of tagging techniques to monitor the utilization of artificial fertilizers by crops, as well as to monitor water management;

-- sterilization of livestock-farm wastes with the object of utilizing them as feeds;

-- tracer studies of processes of assimilation of feed by livestock;

-- use of radioimmunological techniques in early diagnosis of livestock diseases, and in livestock production;

-- radiative techniques of pest control through sterilization;

-- techniques for radiostimulation of crops.

As in the cases of medicine and agriculture, the results here hinge on proper cooperation between agricultural and atomistic centers, meaning both the long-existing cooperation within the framework of the Council and direct agreements and the recently established cooperation between the PAA [State Atomic Power Agency]and the Ministry of Agriculture and Food Management. Specific research and application programs should be drafted jointly. The role of atomistics here too will consist in providing proper working tools, equipment, and isotopes, and assisting in their proper -- from the physical standpoint -- utilization.

As regards radiological protection:

-- studies of migration levels and consequences of radionuclide contamination in the atmosphere and aquatic and terrestrial ecosystems;

-- analysis of the biological consequences of the use of radiation in medicine as compared with other sources of exposure;

-- development of biological microdosimetry and dosimetry.

All the above-indicated directions of development of nuclear and radiation techniques require systematic scientific research with the object of gaining thorough familiarity with the processes being developed, this being the prerequisite for their correct utilization. Systematic research and careful monitoring of the development of basic research projects also are a source of new ideas and new possibilities, which, while hardly if at all considered at present, are certain to appear in the future.

For this reason, it is necessary to continue centrally funded subsidies for applied and basic research into atomistics. Furthermore, continuing support of the cooperation between basic and applied research teams is a condition for achieving practical successes.

Conditions for Implementing the Research Program in Atomistics Until the Year 2000

On considering, against the background of the present situation of Polish atomistics, the factors conducive to the implementation of the goals presented above, the following three groups of factors may be distinguished: those common to the program as a whole; those relating to specific problems of the nuclear power industry; and lastly those relating to the implementation of basic research and to the closely linked program for the development of nuclear and radiation techniques.

In the first group of factors, common to the program as a whole, mention should be made of:

-- systematic advancement and training of science and technology personnel; in view of the aforementioned aging of personnel in atomistics as a whole, and also in view of the anticipated growth in demand for young personnel in connection with the shift to nuclear power generation in Poland, new intensive forms of postgraduate training should be provided for. In addition to the evident contribution of higher educational institutions, the institutes subordinated to the State Atomic Power Agency and their staffs, especially those representing basic sciences, can and should play a major role in this process;

-- activation of a scholarship program that would include foreign-exchange scholarships, for funding training in domestic and foreign institutions;

-- assurance of further development of scientific cooperation with reputable foreign research institutions, intensification of cooperation within CEMA and with MAEA;

-- assurance of influx of foreign periodicals and monographs;

-- equipping the MARIA reactor ith a model-research installation and a PUMA loop, as well as with facilities for radioisotope production;

-- modernization of the EWA reactor;

-- modernization and development of computational facilities for atomistics, and assurance of access to international data banks in the on-line system;

In the second group, the group of factors relating to nuclear power industry, the following should be distinguished:

-- construction of facilities serving to implement the needed scope of research into materials and their compounds (e.g., various kinds of steels);

-- construction of test stands for research into actual operating parameters of the equipment being designed and built for nuclear power generation;

-- construction and opening of a laboratory for research into "hot" irradiated materials and fuels;

-- design and construction of a training center for nuclear power industry, equipped with a full-scale simulation facility.

In the third group of basic sciences and nuclear and radiation techniques, the following are the principal goals:

-- completion of the construction of the Krakow (AIC-144) and Warsaw (U-200p) cyclotrons;

-- construction of pilot plants for the radiative preservation of food, sterilization of medical equipment, and other applications of radiation techniques;

-- completion of the construction of a plasma-focus installation with an energy of 1 MI;

-- regular allocation of foreign exchange for the acquisition and complementation of research equipment;

-- expansion of ZZUJ-POLON [Amalgamated Nuclear Equipment Plants POLON] and of the experimental laboratories of PAA [National Atomic Energy Agency] institutes, so that they could cope with the production of nuclear equipment needed by this country and for exports, which would also serve to obtain foreign exchange to pay for imports; in particular, it is indispensable to:

-- augment the production of CAMAC interconnected electronic systems;

-- initiate the production of the next generation of these systems;

-- develop the production of linear electron accelerators for the needs of medicine and industrial radiography;

-- develop and start the production of industrial accelerators;

-- develop and start the production of cyclotrons for the production of short-lived radioisotopes for medicine;

-- construct rapidly a laboratory of radioimmunological kits for medicine and expand its range of output;

-- decide on and commence by 1990 the construction of a plant for producing radioactive isotopes that would make it possible to broaden markedly the variety of the sealed and bare sources being produced.

It should be yet again emphasized that atomistics serves the entire economy, yielding products and services with an extremely high level of technical thought that are highly profitable economically and generate extremely high indirect effects in the form of improvements in product quality, increased productivity, and improvements in utilization of raw materials. For these reasons, precisely in this country's present situation, both nuclear power industry and the basic atomic-energy sciences and their derivatives -- nuclear and radiation techniques -- should be included among the priority fields in the present era of development of this country.

Warsaw, September 1985

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